Reference values for clinical field tests used in primary based rehabilitation: A South African Case Study

By:

Kamir Baldeo

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Supervisor: Professor SD Hanekom

Co-supervisor: S Nel

Declaration

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Kamir Baldeo

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Abstract

Introduction

Clinical field tests are cheap and easily available tools that are used in primary based rehabilitation. To our knowledge, minimal data is available describing variation in values obtained from field tests in a "healthy" South African context. Reference values are used to assist clinical decisions, define treatment options and determine prognosis. The aim of this thesis was to 1) explore the literature and describe the populations included in establishing reference values for five clinical field tests and 2) describe the values of five clinical field tests in a 'healthy' population from a South African resource restrained metropolitan community.

Methods

The clinical field tests included in this thesis focused on assessing functional exercise capacity; health related quality of life; peripheral muscle strength; grip strength; and respiratory strength. A scoping review was carried out following the framework of (Arksey and Malley, 2005). Six databases were searched from inception to July 2019.

Studies were selected by two independent researchers at title, abstract and full text levels. We used a cross-sectional study design to describe the values for the five clinical field tests in a cohort of healthy South Africans. Convenience sampling technique stratified for age and gender, was used to obtain a sample. Reference values were presented as mean and standard deviation. Scatter plots was used to visually compare the dispersion of the South African values to selected international reference values for exercise capacity and maximal inspiratory pressure.

Results

Nine systematic reviews published within the past five years, were included in the scoping review. Ten additional studies were identified through a secondary search, with nine primary studies reporting maximal inspiratory pressure reference values and one primary study reporting reference values for exercise capacity. The scoping review identified a variety of international populations, procedures, positioning, and reference values. No reference values were identified from populations in least developed countries. Thirty-five participants agreed to participate in the study. The participants were stratified according to six age groups (18-25,26-35,36-45,46-55 and 56-65) and gender. Sixteen participants were male whilst nineteen participants were female. The average age for participants (n=35) were (39.46±13.81), average height (166.4±9.46) and average weight (75.81±19.58). The mean Body Mass Index (BMI) was (27.47±7.24). Of the total sample, participants formed 31.43% of the overweight category and 31.43% of the obese category. The scatter plots visually compared the mean and 95% Confidence Intervals of the South African population to values obtained from international cohorts for the exercise capacity and maximal inspiratory pressure.

Conclusion

The scoping review highlighted the variation in reference values across populations and economic backgrounds as well as differences in testing procedures. Values for five clinical field tests used in primary based rehabilitation has documented normal variation in a healthy South African population. Clinicians need to be cognisant of factors that could impact reference values such as socio-economic environments and the testing procedure. International reference values may be inaccurate for use by clinicians in a South African context. Further work is needed to define more precise South African reference values for the five clinical field tests described in this thesis.

Total Words : 506

Opsomming

Agtergrond

Kliniese veldtoetse is goedkoop en maklik beskikbare instrumente wat gebruik word in primêre rehabilitasie. Na ons wete is daar minimale data beskikbaar wat die variasie in waardes wat verkry is uit veldtoetse in 'n 'gesonde' Suid-Afrikaanse konteks, beskryf. Verwysingswaardes word gebruik om kliniese besluite te fasilteer, behandelingsopsies te bepaal en prognose te voorspel. Die doel van hierdie proefskrif was om 1) die literatuur te verken en die populasies te beskryf wat ingesluit is by die vasstelling van verwysingswaardes vir vyf kliniese veldtoetse en 2) die waardes van vyf kliniese veldtoetse bepaal in n gesonde hulpbron beperkte Suid-Afrikaanse metropolitaanse populasie

Metodes

Die kliniese veldtoetse wat in hierdie tesis ingesluit is, het gefokus op die beoordeling van funksionele uithouvermoë; gesondheidsverwante lewenskwaliteit; perifere spierkrag; greepsterkte; en asemhalingskrag. 'n Literatuur oorisg is uitgevoer na aanleiding van die raamwerk van (Arksey en Malley, 2005). Ses databasisse is ingesluit en die soektog is uitgevoer van die begin van die databasis Studies is gekies deur twee onafhanklike navorsers op titel-, abstrakte- en volteksvlakke. Ons het 'n deursnitstudie-ontwerp gebruik om die waardes vir die vyf kliniese veldtoetse in 'n groep gesonde Suid-Afrikaners te beskryf. Gemaksteekproefnemingstegnieke wat volgens ouderdom en geslag gestratifiseer is, is gebruik om 'n monster te verkry. Verwysingswaardes is as gemiddelde en standaardafwyking beskryf Verspreidingsdiagramme is gebruik om die verspreiding van die Suid-Afrikaanse waardes visueel te vergelyk met geselekteerde internasionale verwysingswaardes vir oefenvermoë en maksimale inspirasiedruk.

Resultate

Nege sistematiese oorsigte wat gedurende die afgelope vyf jaar gepubliseer is, is in die literatuur oorsig ingesluit. Tien addisionele studies is deur middel van 'n sekondêre soektog geïdentifiseer, met nege primêre studies wat die maksimum inspirasie-drukverwysingswaardes rapporteer en een primêre studie wat verwysingswaardes vir oefenvermoë aanmeld. Die bestekopname-oorsig het 'n verskeidenheid internasionale bevolkings, prosedures, posisionering en verwysingswaardes geïdentifiseer. Geen verwysingswaardes is geïdentifiseer van populasies in die minste ontwikkelde lande nie. Vyf en dertig deelnemers het ingestem om aan die studie deel te neem. Die deelnemers is volgens ses ouderdomsgroepe (18-25,26-35,36-45,46-55 en 56-65) en geslag gestratifiseer. Sestien deelnemers was mans, terwyl negentien deelnemers vroulik was. Die gemiddelde ouderdom vir deelnemers (n = 35) was (39.46 ± 13.81), gemiddelde lengte (166.4 ± 9.46) en gemiddelde gewig (75.81 ± 19.58). Die gemiddelde liggaamsmassa-indeks (BMI) was (27,47 ± 7,24).

Van die totale steekproef val 31,43% in die oorgewigskategorie en 31,43% in die vetsugtige kategorie. Die verspreidingsdiagramme het die gemiddelde en 95% vertrouensintervalle van die Suid-Afrikaanse bevolking visueel vergelyk met waardes verkry uit internasionale kohorte vir die oefenvermoë en maksimale inspirasiedruk.

Afsluiting

Die literatuuroorsig het die variasie in verwysingswaardes tussen populasies en ekonomiese agtergronde sowel as die verskille in toetsprosedures beklemtoon. Waardes vir vyf kliniese veldtoetse wat in primêre rehabilitasie gebruik word, het normale variasie in 'n gesonde Suid-Afrikaanse bevolking aangetoon. Klinici moet kennis dra van faktore wat die verwysingswaardes kan beïnvloed soos die sosio-ekonomiese omgewings en die toetsprosedure. Internasionale verwysingswaardes kan onakkuraat wees vir gebruik deur klinici in 'n Suid-Afrikaanse konteks. Verdere werk is nodig om meer akkurate Suid-Afrikaanse verwysingswaardes te definieer vir die vyf kliniese veldtoetse wat in hierdie proefskrif beskryf word.

Totale aantal woorde: 497

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Contents

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List of Abbreviations

1. 6MWD - Six Minute Walk Distance
2. 6MWT - Six Minute Walk Test
3. ADL – Activity of Daily Living
4. AMSTAR - A Measurement Tool to Assess Systematic Reviews
5. ASHT – American Society of Hand Therapists
6. ATS - American Thoracic Society
7. BF – Brittany Fell
8. BMI – Body Mass Index
9. CI – Confidence Interval
10. CINAHL – The Cumulative Index to Nursing and Allied Health Literature
11. COSMIN - Consensus based Standards for the selection of health status Measurements Instruments.
12. EMBASE – Excerpta Medica Database
13. EQ-5D-5L – Euroqol – 5 dimension – 5 level tool
14. ERS – European Respiratory Society
15. HRQoL – Health Related Quality of Life
16. IFCC – International Federation of Clinical Chemistry
17. IQR – Inter-quartile Range
18. LCI – Lower Confidence Interval
19. LILACS – Latin American and Caribbean Health Sciences Literature
20. MEDLINE – Medical Literature Analysis and Retrieval System Online
21. MIP - Maximal Inspiratory Pressure
22. MRC – Medical Research Council
23. MVIC – Maximal Voluntary Isometric Contraction
24. NCD – Non-Communicable Disease
25. PHC - Primary Health Care
26. PI – Principle Investigator
27. PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses.
28. QUADAS – Quality Assessment of Diagnostic Accuracy Studies
29. REDCAP – Research Electronic Data Capture
30. SAJP -South African Journal of Physiotherapy
31. SciELO – Scientific Electronic Library Online

List of Abbreviations

32. SD - Standard Deviation
33. SH – Professor Susan Hanekom
34. TB – Tuberculosis
35. TBH – Tygerberg Hospital
36. UCI – Upper Confidence Interval
37. VAS – Visual Analogue Scale
38. WESP – United Nations World Economic Situations and Prospects
39. WHO – World Health Organization
40. KB – Kamir Baldeo

Glossary

1. Clinical Field Test – A clinical field test is a cheap and portable tool used to measure health related fitness outcomes (Tveter, 2014).

2. Economy – The status of wealth and availability of resources in terms production and services rendered by a country (Situation, 2015).

3. Evidence Based Practice – The practice of clinical decision making by health care professionals, informed by current evidence specific to context and the availability of resources ('Toward a Transdisciplinary Model of Evidence-Based Practice', no date).

4. Exercise Capacity – A multiple system response to a set workload placed on an individual, resulting in the maximum intake of oxygen. This is referred to as their exercise capacity (Arnsdorf, Merz and Lauer,2005).

5. Non-communicable disease – A disease that cannot be transmitted from one individual to another (Mayosi *et al.*, 2009).

6. Rehabilitation – A structured process of clinical decision making to solve disability related issues caused by disease (Behind and Rehabilitation, 2003).Reference Value – A value that is produced through a quantitative measurement of a reference point orindividual (Friedrichs *et al.*, 2009).

7. Limb muscle strength - Limb muscle strength can be defined as the maximum voluntary force that an individual needs to exert under specific environmental conditions (Bohannon, 1997).

8. Break test – A break test is performed when an assessor applies a force with a Hand-held dynamometer against an individual's limb as they exert a maximal force that is overcome by the assessor (Stratford and Balsor, 1994).

9. Make test – A make test is performed when a Hand-held dynamometer is held stationary against an individual's limb as they exert a maximal force against the dynamometer and assessor (Stratford and Balsor, 1994).

10. Primary Based Rehabilitation – Essential rehabilitation services that are easily available, inexpensive and scientifically appropriate (White, 2015).

1 Chapter 1 - Introduction

The concept of the reference value was first established in 1969 by authors, Grasbeck and Saris. The primary focus of these authors were to identify changes in concentrations of blood analyte in a specific cohort of defined individuals (Friedrichs *et al.*, 2009). Initially, 'normal values' was commonly used and described as a normal range between a mean ± two standard deviations (Gra, 2004). The term 'normal values' presented more than one definition and thus the term 'reference value' was later developed (Friedrichs *et al.*, 2009). Friedrichs *et al.*,(2009) described a reference value as a value that is produced through a quantitative measurement of a reference point or individual. Similarly, (Gra, 2004) described reference values as data that is necessary when analysing and understanding observations in the medical field. The applicability of reference values go beyond the field ofclinical chemistry (Federation and Clinical, 1987).

The concept of the reference value was further critiqued as criteria was necessary to produce a reference value. Reference values are considered purposeful if the methodology required to produce the reference value is described. This entails outlining the selection criteria for the reference individual, data collection method, environmental and physiological effects during testing and data analysis method (Federation and Clinical, 1987).It is commonly taken that reference values only measure 'normal' or 'healthy' individuals (Gra, 2004).The International Federation of Clinical Chemistry (IFCC) recommend that the current condition of health inclusive of disease needs to be stated prior to 'reference value' which in turn is referred to as a current state of health (Gra, 2004).

'Normative' reference values suggest that references need to be developed for a healthy individual. The World Health Organization (WHO) currently defines health as ," a state of complete physical, mental and social-wellbeing and not merely the absence of disease or infirmity."(Who, 2006). A study by Horst *et al.*,(2011) highlighted that as the trend of disease changes along with an ageing population, the definition of health by the World Health Organization (WHO) is not useful. Horst *et al.*,(2011) further highlights that the World Health Organization (WHO) definition of health does not account for individuals with disabilities or suffering from chronic diseases and concludes these individuals to portray definite poor health. This is relevant and important to consider when identifying 'healthy' in a South African context due to the high burden of non-communicable disease (Mayosi *et al.*, 2009). A state of health can be seen as not definite but rather relative depending on variation between populations, within populations and as populations age over time (Federation and Clinical, 1987).

The understanding of the range of normative differences and link to physical outcomes is crucial in many areas of healthcare including primary based rehabilitation (Mckay *et al.*, 2012). Once normal variation has been understood, deviation from this variation can be identified and responses to clinical approaches can be placed under scrutiny (Mckay *et al.*,2012). Comparison with normative reference values assist respective clinicians with clinical decision making that involve diagnosis, management,prevention and emphasis on possible clinical significance (Mckay *et al.*, 2012). Any identified clinical significance encourages evidence-based guidance when making clinical decisions in primary based rehabilitation (Johnson, Lynch and Hermann, 2015). Normative reference values and reference equations are needed to improve the clinical value and interpretabilityof clinical field tests (Tveter *et al.*, 2014).

Clinical field tests are widely used in primary based rehabilitation to measure specific outcomes through which reference values are developed. Clinical field tests are measurement tools that are available and easy to use, that require no or only portable equipment. Health related quality of life (HRQoL), physical and functional outcomes are measured by means of these field tests even though the tests may be less accurate due to varying inter-rater reliability and not as specific as laboratory-based tests (Tveter, 2014). Many studies have reported that different clinical field tests explore different aspects of health-related physical activity. The five clinical field tests chosen had a dual reason as 1) they provide us with information regarding the health of an individual overall and 2) this study forms the control study for a larger research project, the clinical tests were chosen in accordance to the larger research programme that is focusing on five clinical field tests relevant to a Tuberculosis (TB) population. Results obtained from a clinical field test needs to be compared to normative results to detect any changes in health status that can be further guide clinical decisions. For the clinical field testto be of value the clinical field test needs to be standardized, specific and user friendly (Hammond and Unit, 1998).

The six-minute walk test (6MWT) assesses functional exercise capacity, dynamometry measures hand grip strength and peripheral muscle strength and maximal inspiratory pressure testing investigates the strength of the respiratory muscles on inspiration. Inspiratory muscle strength is the direct measure of the developing pressure within the thorax tested by performing a forceful inspiration against an occluded mouthpiece (Mb *et al.*, 2014). Limb muscle strength can bedefined as the maximum voluntary force that an individual needs to exert under specific environmental conditions (Bohannon, 1997). Maximum Voluntary Isometric Contraction (MVIC) can be measured with handheld dynamometers, which are inexpensive and a quick method of manual muscle testing (Meldrum *et al.*, 2007). The six-minute walk test (6MWT) examines the submaximal level of functional exercise capacity and assesses the responses of multiple body systems during exercise (Issues *et al.*, 2002). Hand Grip Strength is the result of a force created by deep and superficial muscles during the activity of gripping. Handgrip strength is said to be an objective indication of mucle strength and current health status (Mgbemena, 2019).

It is possible that populations across the world may differ in clinical field test outcomes. According to Collier, (2007), Africa has not been growing in terms of income level and resolving poverty thus making it difficult to escape economic stagnation. It is uncertain if this holds true till date. Socioeconomic status has become an important determining factor of health (Peterson *et al.*, 2006). It would be necessary to consider that factors such as varying economic backgrounds may affect clinical field test outcomes and thus varying reference values between populations. Furthermore, it can be speculated that populations from developed economic backgrounds can achieve better clinical field test outcomes due to access to better education, access to physical exercise institution and prevalence of NCD. South African is categorised as a developing economy according to the World Economic and Situations Prospect 2019 (WESP). A decrease in physical function occurred with a decrease in employment in participants with or withoutdisease, thus suggesting that socioeconomic status can play a role in the outcome of clinical field tests (Peterson*et al.*, 2006).

The aim of this thesis was to 1) explore the literature and describe the populations included in establishing reference values for five clinical field tests and 2) describe the values of five clinical field tests in a “healthy” population from a South African resource restrained metropolitan community.

1.1 Thesis Overview

The thesis comprises of four chapters (Figure 1.1). The scoping review (chapter two) aimed at identifying international reference values which further informed the second aim of the thesis, identifying the need for South African reference values, after comparing to the results of the primary study (chapter three). Chapter three is written according to the South African Journal of Physiotherapy (SAJP) guidelines for an original article submission. Therefore, in chapter two we have explored the literature presenting existing international reference values for the forementioned clinical field tests. We have summarized populations included, through descriptive statistics, methodologies used, and procedures followed. In chapter three, our primary study, we have described age and gender specific values for five clinical field tests from a sample of 'healthy' South African adults with the intention to identify an overlap with international reference values. The results of our chapter two and three will aim to inform the need to establish South African reference values through an overall discussion in chapter four. The reference list for the thesis is collated as one. An individual reference list will be created for the article to be submitted for further publication. All documents related to the execution of the study is summarised in Addenda.

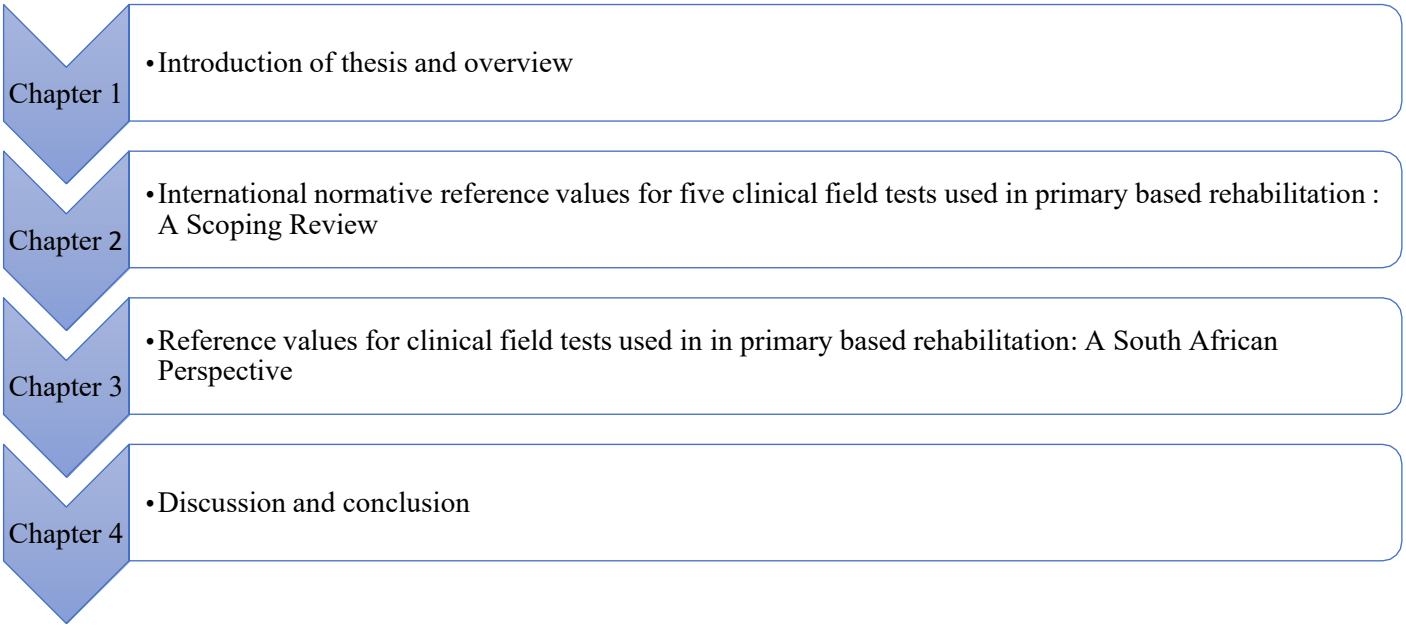

Figure 1.1 Flow diagram: Thesis Overview

2 Chapter 2 – Scoping Review

2.1 Introduction

The understanding of the range of normative differences and physical function is crucial in many areas of healthcare and physiotherapy (Mckay *et al.*, 2012). Comparison with normative references aid clinical decision making that involve diagnosing, management and prevention of disease (Mckay *et al.*,2012). Once normal variation has been understood, deviation from this variation can be identified and responses to treatmentcan be placed under scrutiny (Mckay *et al.*, 2012). The concept and philosophy of the reference value has been widely used in the fields of clinical chemistry and laboratory medicine and have promoted the relevance inmany other fields of study (Federation and Clinical, 1987). Authors, Grasbeck and Saris had first identified the use of 'normal values' when observing changes in concentration of blood analyte (Friedrichs *et al.*, 2009). Friedrichs *et al.*,(2009) had also decided that the term normative 'reference value' may be more definitive than 'normal values'. According to (Gra, 2004), the term normative reference value has been said to be ambiguous and definitive terms and procedures need to be put in place when developing normative reference values. Normative reference values have been described as a spread of values of biological origins chosen according to definitive criteria and derived from a homogenous and healthy group of individuals (Henny, Petitclerc and Fuentes-, 2000).

Similarly Friedrichs *et al.*,(2009) describes a normative reference value as a quantity that has been observed and measured on a reference individual. Whilst normative reference values had also been described as obtaining values from a generally healthy population, obtaining values from a population that is not admitted in hospital and individuals said to have been healthy is not the same (Gra, 2004). The International Federation of Clinical Chemistry (IFCC) recommends with great importance that the respective population state of health be distinct when developing normative reference values (Henny, Petitclerc and Fuentes-, 2000).Whilst the description of normative reference values have been stated subjectively, objective descriptions of normative reference values have been described as executing a number of tests on groups of healthy people where ± two standard deviations are taken and the values between end values are a representation of normative reference values (Gra, 2004). Regardless of the ambiguity of which the term portrays and the field in which the normative reference value is being developed, the central idea being relayed is to create values that will be an aid in the analysis and differentiation of clinical and medical observations.

Many issues have been discovered when determining reference values, of which one of the main issues being able to decide on criteria to define a healthy population group (Friedrichs *et al.*, 2009). This in turn stimulates the discussion circulating around the definition of health. In 1948, the World Health Organisation (WHO) defined health as, "state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity." Horst *et al.*,(2011). As time progressed this definition had become problematic as according to (Leonardi, 2018), the ageing rate had increased and populations with chronic ailments and disabilities had survived a longer period than predicted. It can be considered that a population requires stringent criteria to define a current state of health of a population, than having rather excluded the population group indefinitely if deemed not healthy. Friedrichs *et al.*,(2009) also agreed, that a normative reference value should be obtained from a healthy reference and this in turn raises concerns around defining 'healthy' once again. According to Gra,(2004), it is the usual that normative data had been obtained from the university staff, young students and the professor. In contrast, this had not been the case as Gra,(2004) declared that when taking reference values from any participant, the detailed method of assessment, criteria selecting the individuals and state of current health inclusive of poor health be at the forefront of importance. It is quite clear that Gra,(2004) does not consider normative references being necessarily derivative of a 'healthy' individual, as the author describes 'state of health' inclusive of disease thus prompting a strict selection criteria when selecting a individuals contributing to normative references values. Federation and Clinical, (1987) supports this statement regarding 'state of health' as they further describe health to be in a state of relativity rather than absolute when explaining health as submissive to change in terms of varied global perspectives and phases during an individual's life.

Normative reference values have been developed to allow for identification if deviations from the reference occurs (Gra, 2004). We argue that in order to develop normative reference values, the values need to be takenfrom an apparently healthy individual especially if being used in a control group. Gra, (2004) mentioned the importance in how the weak points or differences become apparent when using normative references as a control group. For a normative reference value to be of value it is imperative that its origin, the procedure carried out to assess the reference value, sex, age and ethnic groups involved, to be specified (Gra, 2004). Reference values can be developed for either a healthy population or a diseased population. The term 'normativereference value' will be used to describe a healthy population.

South Africa is an ethnically and socially diverse middle income-country (Myer, Ehrlich and Susser, 2004). According to the World Economic Situation and Prospects guideline (WESP), South Africa is classified as a developing economy. It has been proposed by (Myer, Ehrlich and Susser, 2004), that developed economies of the world differ from that of South Africa. Developed countries are fully equipped with resources unlike developing countries such as South Africa that carry 85% of the worlds burden of disease (Cooperation and Bureau, 2020). When considering the connection between health and socio-economic status, it can be argued that the health of the South African population would be different from populations residing in the developed world. The idea that socio-economic background may have an effect on normative reference values, is supported by a study (Ramlagan, Peltzer and Phaswana-mafuya, 2014) that analysed hand grip strength in the older South African male population. Ramlagan, Peltzer and Phaswana-mafuya, (2014) reported that hand grip strength improved with an increase in financial standing and education obtained.

While widely accepted that other factors like age, sex and occupational factors of the population could also affect the interpretation of the values, the interdependency of various factors impact reference values and ultimately the clinical utility. Ramlagan, Peltzer and Phaswana-mafuya,(2014) reported that older South African men had adecrease in hand grip strength compared to men in European countries whilst in contrast, South African women had an increase in hand grip strength compared to woman in European countries. It can be speculated that the difference is due to different occupational and gender-based roles between economies. The following questions then arise: 1) which populations have been sampled in describing reference values for specific field tests; and 2) which factors have been identified to impact the reference values.

In health, therapists and other health practitioners routinely utilise field tests. Measurements carried out by portable and inexpensive tools are referred to as clinical field tests. Often times field tests prove more feasible than administering gold standard tests (Tveter, 2014). Eaton *et al.*,(2006) also describes field tests as being more practical than the gold standard tests or laboratory-based exercise testing. The increasing demand placed on primary care rehabilitation by the increasing rate of non-communicable disease (NCD) in developing economies, requires implementation of less expensive interventions (Beratarrechea *et al.*, 2014). Eaton *et al.*, (2006) compared two walking field tests in a chronic lung disease population and described the tests as effective and simple. Field tests provide an inexpensive tool useful for rehabilitation at primary care level in a developing country such as South Africa (Hammond and Unit, 1998). Measurements obtained by clinical field tests and outcome measures are crucial when identifying whether significant health related changes have occurred and inform clinical decision making when planning a treatment. Whilst Tveter, (2014) emphasized the importance of clinical field tests in assisting clinical decisions made by practitioners, the lack of accuracy and specificity when compared to laboratory based tests need to be considered.

The tester should always consider the possibility of inaccuracy. It is thus necessary when assessing normative reference values to identify international variations of reference values to establish whether there is a need to develop new reference values or make use of a potentially similar international normative reference value.

The five field tests are used to assess maximal inspiratory pressure, exercise capacity and muscle strength of the upper limbs and lower limbs. The tests will provide useful data when assessing respiratory conditions, frailty and deconditioning within non-communicable disease at a primary care level, and making an informed decision regarding therapeutic exercise, holistic management, and education.

2.2 Research Question:

"Which populations have been included in the development of reference values for five clinical field tests used in primary based rehabilitation?"

2.3 Research Aim:

To map and compare the populations which have contributed to the development of normative reference values for five clinical field tests used in primary based rehabilitation. The five clinical tests include grip strength, Deltoid strength, Quadricep strength, maximal inspiratory pressure (MIP) and the six-minute walk test (6MWT).

2.4 Objectives:

2.4.1 Primary Objectives

To identify and document the reference values and distribution for the five clinical field tests.

To describe the origin of populations used to obtain reference values for the five clinical field tests.

To describe the demographics of the populations included to obtain reference values for the five clinical field tests.

2.4.2 Secondary Objectives

To map and compare the factors which have been documented to have an influence on reference values.

2.5 Methodology

We followed the first five stages of the framework published by (Arksey and Malley, 2005) to identify and map the existing literature reporting on reference values for the five field tests. We decided not to include the consultation stage of the framework at this stage but will use the results of the review to engage with the rehabilitation community in the future. As we became more familiar with the literature for each field test, we added or amended the framework stages to provide a clear picture of the existing literature. The amendments of the framework stages are described.

Step 1: Formulating a question

Step 2: Identifying studies

Step 3: Selecting the studies

Step 4: Charting the data

Step 5: Collating, summarizing, and reporting

Step 6: (Optional) – Consultation with stakeholders in the future

2.5.1 Identifying studies

A subject specific search strategy was developed for each of the five different subject areas namely, grip strength, Quadricep strength, Deltoid strength, maximal inspiratory pressure and the six-minute walk test. Six electronic bibliographic databases namely CINAHL, MEDLINE, Science Direct, Scopus, PubMed and Web of science were searched from database inception to July 2019. Searches were completed independently for each clinical field test. The number of retrieved studies is reported collectively for all clinical field tests in (Figure 2.1). Search terms and limits applied are available in (Addendum K).

If a systematic review and/or Meta-analysis was not published in the past 5 years, we completed a secondary search for primary studies in the relevant field test. A detailed presentation of the search strategy, inclusion/exclusion criteria and selection process of the studies will be detailed in each respective clinical field test. The search strategy, keywords and selection process illustrated by a flow chart for the secondary search for primary studies is attached in (Addendum J,L and M). An illustration of the identified studies for each clinical field test and the clinical field test where a secondary search for additional studies has been made clear (Table 2.2).

2.5.2 Selecting the studies

The studies returned by the search strategy were screened for inclusion at abstract, title, and full-text level by two independent reviewers. The Primary Investigator (PI) and the secondary reviewer, Brittany Fell (BF) systematically screened all papers independently. Studies were included in the screening process if they had reported normative reference values in both genders, studied human subjects, carried out a systematic review and/or a meta-analysis. In the event of a disagreement, a discussion to reach consensus was organized between the two reviewers. If consensus could not be achieved, a third reviewer, Professor Susan Hanekom (SH) was consulted. Full-text papers were retrieved by accessing online electronic journals.

Systematic reviews and meta-analysis' exploring and describing normative reference values of the five clinical field tests were prioritized for inclusion into the review. The total number of searched hits from the selected databases across the five clinical field tests included 353 studies. Three hundred and thirty-four studies were excluded in total. Studies reporting on children, adolescents, high performing athletes, diseased populations, and non-English reviews were excluded. The same inclusion and exclusion criteria (Table 2.2) was executed in each subject area, throughan iterative process after the search was conducted. In (Figure 2.1), the primary search selection process followed collectively over all five field tests to result in nine included studies, is illustrated.

Table 2.1 Study Selection Criteria

Inclusion criteria	**Exclusion criteria**
Normative reference values including both genders Human Studies Systematic Reviews Meta-analysis	Non-English papers Reference values for a diseased population/ population with a condition Reference values for athletes and high performing individuals Reference values for children and adolescents Endurance testing Research protocols Research Reports

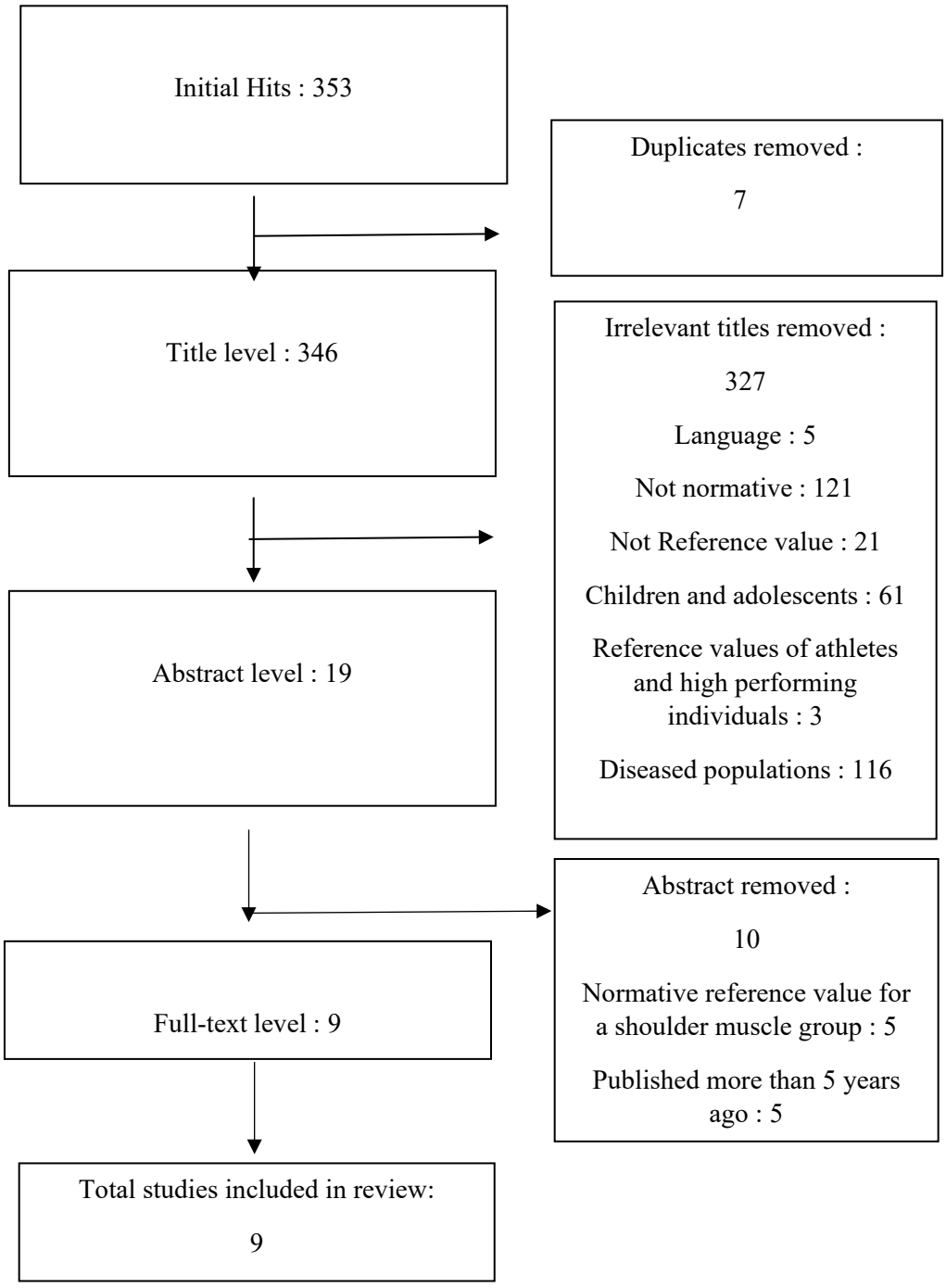

Figure 2.1 Selection Process Flow Diagram : Overall

Table 2.2 A Summary of retrieved systematic reviews and primary studies

Clinical field test	Primary Search		Secondary Search	
	Author and date published: systematic review	**Systematic reviews (n=)**	**Author and date published: Primary study**	**Primary studies (n=)**
Muscle strength	Benfica et al.(2018)	3	No secondary search conducted	No secondary search conducted
	Bohannon et al. (2011)			
	Bohannon et al. (2018) - updated			
Grip strength	Bohannon et al. (2006)	5		
	Bohannon et al. (2006) - updated			
	Dodds et al.(2016)			
	Kamide et al.(2015)			
	Benfica et al.(2018)			
MIP	Pessoa et al.(2014) (Studies included up until 2011)	1	Pessoa et al.(2014)	1
6MWT	Salbach et al.(2015) (Studies included up until 2013)	1	Mosharraf-Hossain et al.(2014)	9
			Britto et al.(2013)	
			Zou et al.(2017)	
			Zou et al.(2017)	
			Shrestha et al.(2015)	
			Ajiboye et al.(2014)	
			Bourahli et al.(2015)	
			Tveter et al.(2014)	
			Rao et al.(2013)	
Total retrieved		10 including duplicate: Benfica et al.(2018)		10

2.5.3 Charting of data

The Primary Investigator (PI) extracted and charted relevant data from the included papers on to a excel spreadsheet for each field test. A detailed report will be included in each subsection. The data extracted and charted included year of publication; number of relevant articles included in meta-analysis; total number of relevant articles; guidelines followed; method of data analysis; search terms and strategies used; databases accessed; type of instrument used; procedure and positioning; the country of which the study was conducted in; age group/groups of participants involved and description of respective normative reference values.

2.5.4 Collating, summarising and reporting

2.5.4.1 Assessment of Methodological Quality

While quality assessment is not included in the framework of (Arksey and Malley, 2005), a quality assessment of the included studies in this review have been included. It can be argued that the additional information will be valuable in identifying potential issues in the existing literature and informing the design of future studies. Tothis end we have included tools to assess methodological quality. The tools used in each of the subsequent sections will be identified. In this section, we describe the different tools and the process used in completing the quality assessment.

2.5.4.1.1 AMSTAR: A Measurement Tool to Assess Systematic Reviews

The AMSTAR tool was initially designed in 2007 to evaluate systematic reviews of randomized controlled trials. The AMSTAR-2 tool was later developed to include non-randomized studies. The AMSTAR-2 will be used to assess methodological quality over 16 items and will provide an overview of any apparent weaknesses in seven critical domains. Two reviewers, (KB and BF) independently assessed the methodological quality of the systematic reviews using AMSTAR-2. Any discrepancies between the two assessors for each domain was identified and discussed reflecting on rationale used to assess the item of concern. The differences were resolved when an agreement had been reached by both assessors.

2.5.4.1.2 COSMIN: Consensus based Standards for the selection of health status Measurements Instruments.

The Consensus based Standards for the selection of health status Measurements Instruments (COSMIN) is a tool comprising of checklists to assess the quality of studies included in the systematic review under the exercise capacity subsection. The tool was used only in this section to assess the quality of an additional study according to the same specific checklist used within the COSMIN tool for the systematic review. This was to allow the results between the additional studies and systematic review to be comparable and provide potential flaws or strengths in the quality of the studies.

2.5.4.1.3 McMaster Critical Review for Quantitative studies

The McMaster Critical Review was developed by the Occupational Therapy Evidence-Based practice research group of McMaster University (Form and Studies, 1998). This critical review form provides a simple guideline that can be understood by students, clinicians, and academics. Additional articles were assessed according to an item checklist under eight main sections (study purpose, literature, design, sample, outcomes, intervention, results and conclusions and implications) with four subsections. You can either answer as “Yes”, “No ” or “Not Addressed”. For every answered “Yes”, a score of 1 is given and the total score is given out of 15 as a total reflection of the quality of the assessed study.

In the following subsections, each field test will be described separately.

1) Muscle strength
2) Exercise Capacity
3) Maximal Inspiratory Pressure (MIP)
4) Grip Strength

2.6 Exercise Capacity

2.6.1 Identification of studies

Salbach et al. (2014) was identified as the latest comprehensive systematic review, summarizing data on time and distance limited walking tests and reference equations. The systematic review limited papers published from inception to 2013. We thus completed a secondary search identifying a further nine primary studies dated from 2013 onwards that were not included in the comprehensive systematic review. The additional studies will provide a further update of Salbach et al. (2014). A detailed table attached in (Addendum L) describes the databases accessed and search strategies used.

2.6.2 Selection of studies

The inclusion and exclusion criteria in (Table 2.1) was used to identify eligible studies. The specific selection process is illustrated in (Figure 2.3). One systematic review was included after irrelevant titles and abstracts had been removed. The secondary search strategy, databases accessed, and selection process flowchart is attached in (Addendum J,L and M).

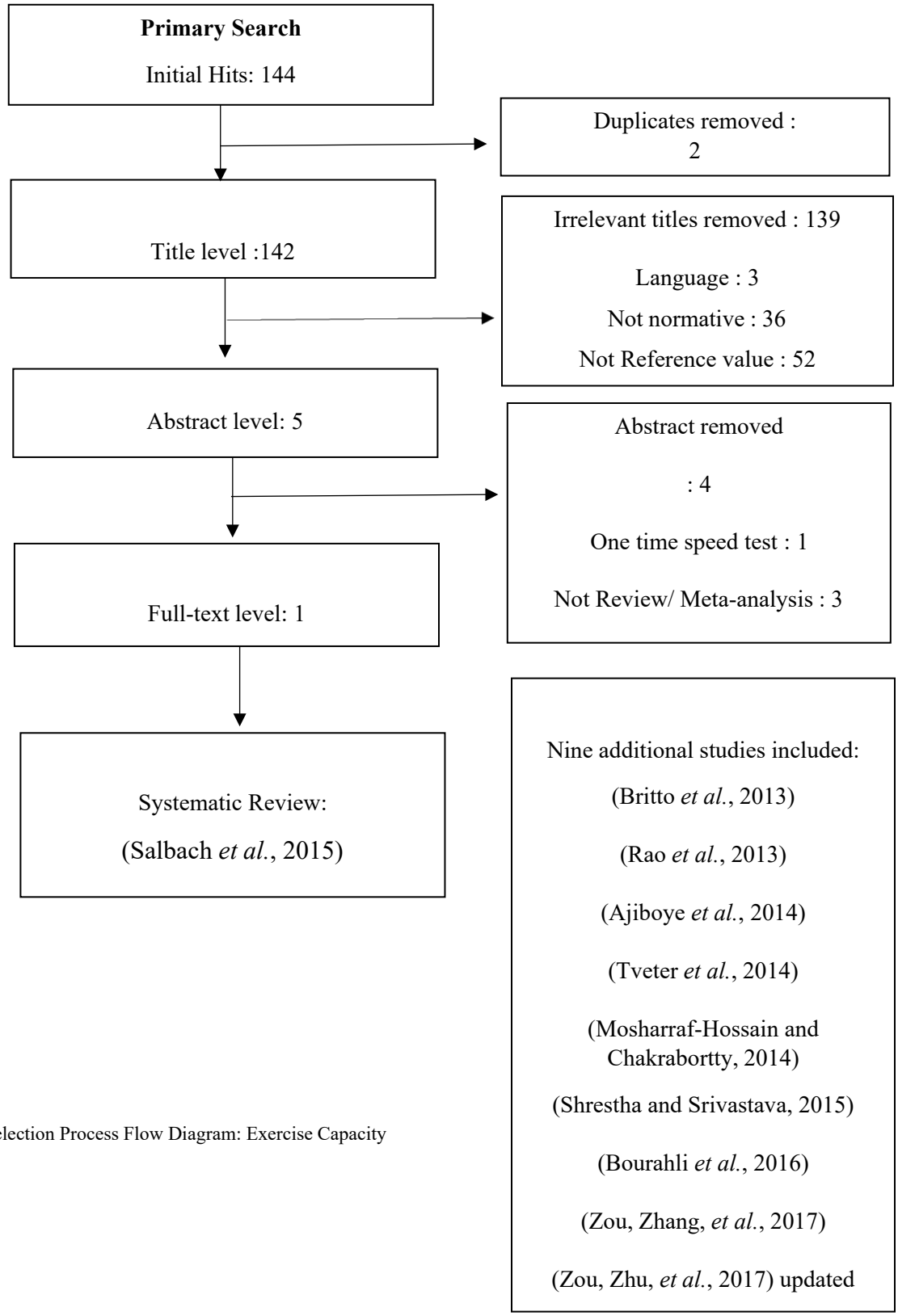

Figure 2.2 Selection Process Flow Diagram: Exercise Capacity

2.6.3 Charting of data

We recorded the data extracted from the 15 studies that were included in the systematic review. The data extracted were only applicable to time limited tests either walking a 30m course or adapted type of walking course. We used the same datasheet as the systematic review to extract the data from the nine additional primary studies that had not been included in the systematic review. A summary of the (n=24) studies are tabulated in (Table 2.6). It has been indicated as to which of the studies were included in the systematic review.

2.6.4 Collating, summarising and Reporting

2.6.4.1 Methodological Appraisal of additional nine studies

Fifteen studies were included in the systematic review (Salbach *et al.*, 2015)**.** The main methodological issues identified by (Salbach *et al.*, 2015) revolved around a failure to describe the method used to select participants in 48% of included studies, an inadequate sample size in 28% of included studies, failure to report scores and change scores for relevant subgroups in 12% of included studies and 87% of studies were of convenience sampling types.

The methodological quality of the nine additional studies were assessed according to the same checklist used by Salbach et al - item-level (COSMIN) - to ensure consistency (Figure 2.3). Although less prevalent, methodological concerns regarding poor representation of the sample population persist. Twenty two percent (n=2) of the additional primary studies reported using a random sample, while 22% (n=2) of studies failed to report a method used to select participants and 55%(n=5) of the studies reported using a randomized sample. Important flaws in study design had been reported in 11% (n=1) of the studies. The important flaws highlighted included asingle study that had not reported the design of the study. Eighty nine percent (n = 8) of studies reported adequate sample size whilst this item had been marked as “uncertain” for a single study. Rao *et al.*, (2013), recommended that further studies need to be carried out with a greater sample size thus causing uncertainty. A newmethodological issue derived from the nine additional studies had been that of selection bias. Many of the nine studies (n=6) detailed limitations of selection bias such as recruitment of willing, motivated, and healthy participants.

Another methodological issue common between the nine additional studies and (Salbach *et al.*, 2015) was that of questionable eligibility criteria. Salbach *et al.*,(2015) found that a ‘healthy participant’ can be criticised as studies included large numbers of participants in the overweight, obese, and smoking categories. Thirty three percent (n=3) ofthe additional nine studies excluded participants in the overweight and underweight categories according to theBody Mass Index (BMI) Classification.

Salbach *et al.*,(2015) reported descriptive reference values according to mean and standard deviation for thirty studies and median for a single study, mean and standard deviation were the statistical method of description chosen for all nine additional studies. This commonly chosen method of statistical analysis is in support of the aim of describing the normal distribution of normative reference value data. All nine studies have been stratified according to gender, however, not to age groups. Thirty three percent (n=3) of studies stratified data according to age groups whilst 50% of the six remaining studies were either had not reported stratification of age groups or described therange from youngest to the oldest participant.

Salbach *et al.*,(2015), had identified that in the age group mean of fifty and older, larger sample sizes to improve precision are necessary due to the increase in disability in older age groups. The main cause of the inadequate sample sizes in the older age groups had been due to difficult recruitment. Furthermore, of the nine additional studies that had taken this methodological issue into account, Tveter *et al.*,(2014) further recommended that variables such height, weight and gender, should be the basis of which precise estimates of reference values inthe age group of fifty and older should be considered.

In summary, appraisal of the nine additional studies highlighted three issues with respect to sampling: 1) uncertainty regarding adequate sample size, 2) stratification according to age groups in only 50% of included studies, 3) the presence of selection bias when recruiting participants of a sample. All studies were carried out according to the American Thoracic Society guidelines (ATS) when performing the six-minute walk test. This had either been explicitly reported in the methodology or found in the list of references.

Figure 2.3 Quality Appraisal (COSMIN) of nine studies assessing the six minute walk distance.

Green represents 'Yes' whilst Red represent 'No'.

Abbreviations: I = Interpretability Checklist, G = Generalizability

'+' = Yes, ' – ' = No, ? = Uncertainty.

2.6.4.2 Geographical Distribution and Demographics

The Geographical distribution of the included studies from the systematic review, (Salbach *et al.*, 2015) was categorized at economy level according to developed, developing and least developed economy illustrated in (Figure 2.5). The Geographical distribution of the nine additional studies are illustrated in (Figure 2.6). Further studies have been produced by developed economies in the middle eastern region included in the additional studies adding a new developed economy not included in the systematic review. Similar developing economies have been included in both the additional studies and systematic review besides Northern African developing economies not included in the systematic review. No studies had been conducted in least developed economies.

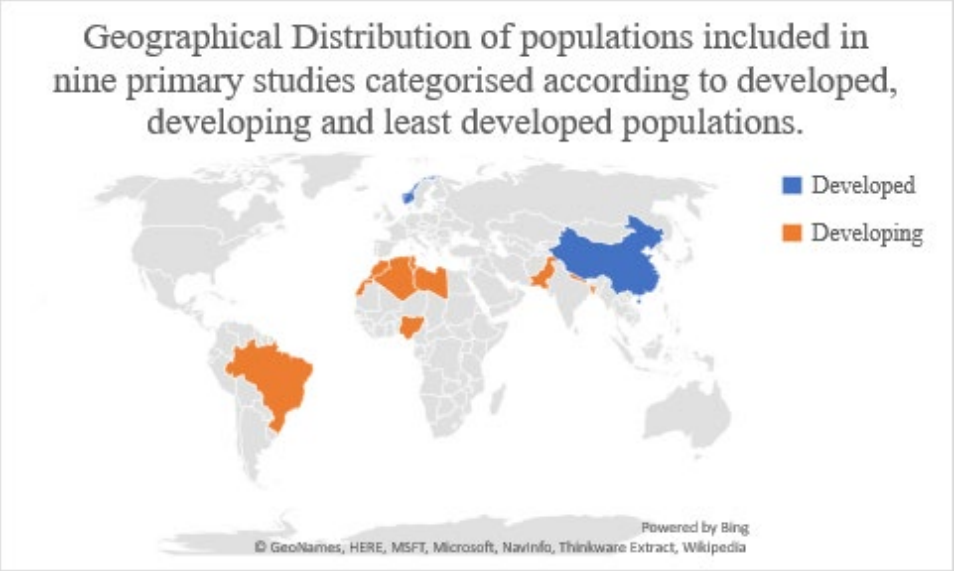

Figure 2.4 : Geographical Distribution of populations : Exercise Capacity

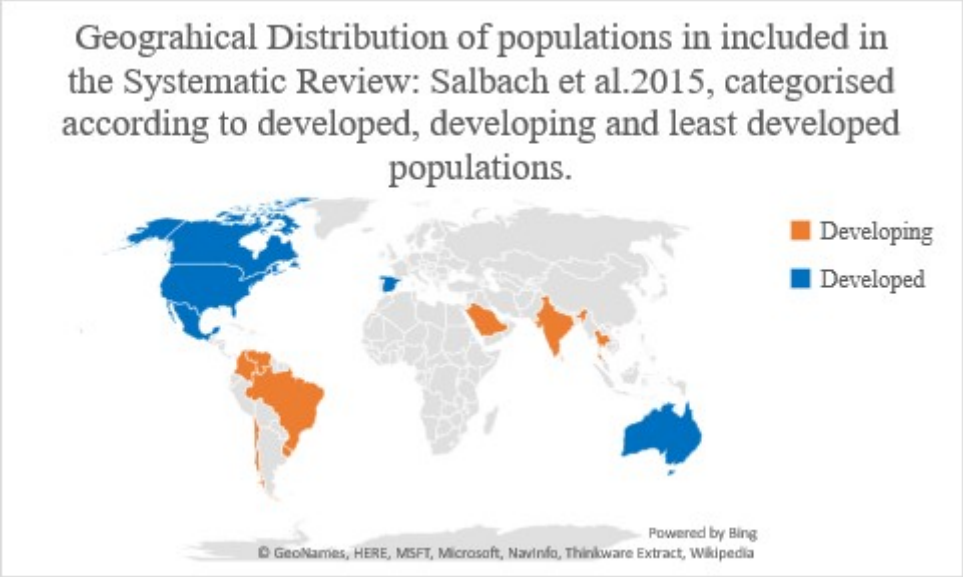

Figure 2.5 : Geographical Distribution of populations : Exercise Capacity

2.6.4.3 Study, walk test protocol and participants characteristics included in both the systematic review and nine additional studies for six minute time limited walking test.

The country, pathway, age group and normative reference value for 24 studies have been tabulated to provide an overview of the current available and updated normative reference values, walk test protocol and participants characteristics (Table 2.3). The table has been organised alphabetically, according to the pathway walked and if a study has been included in the systematic review, (Salbach *et al.*, 2015). Fifteen (n=15) studies have been included in the systematic review of which (n=6) studies report measuring the six-minute walk distance (6MWD) over a 30m standard pathway and (n=9) reported measuring the six-minute walk distance (6MWD) over an adapted distance of which (n=2) studies were published before ATS guidelines were developed. Nine of the studies have not been included in the systematic review and provide new normative reference value data from different countries. (n=7) of the nine additional studies reported measuring the six- minute walk distance (6MWD) over a standard 30m pathway whilst (n=2) of the additional studies reported measuring the 6MWD over an adapted distance. Thus 50% (n=12) of all studies reported 6MWD over a 30m standardized pathway whilst 50% (n=12) of all studies reported measuring the 6MWD over an adapted distance.

Under further analysis of the distances and courses walked, 45.83% (n=11) reported walking a standardized 30m "straight" pathway whilst 33.33% (n=8) reported walking adapted distances according to a "straight" pathway. In contrast, one study reported the shape of the pathway walked over an adapted distance as rectangle (6m x 4m). All other included studies failed to report the shape of the pathway walked. A variation of adapted distances reported had been identified in 50% of included studies, whilst the other 50% included only a standardised 30m distance. 12.5% (n=3) of studies following an adapted distance walked 45m and 8.33% (n=2) walked 15m, whilst six studies walked 20m, 82.3m, 13.3m, 25m, 18m, 45.7m, respectively. In terms of pacing, 29.17% (n=7) studies reported that participants had been encouraged to walk at their own pace whilst 16.67% (n=4) studies reported that participants had been encouraged to walk as fast as possible. One study included in the systematic review, Padron et al.2000, used a 25m adapted walking course and had participants performing the walk twice at both a slow and fast pace.

Of all studies included in the systematic review and nine additional studies, 33.33% (n=8) reported having performed one trial and thus not accounting for a potential learning effect. Twenty five percent (n=6) reported performing two trials, 20.83% (n=5) reported performing three trials and one study reported performing four trials with varyingtime periods between each trial. The reported period interval varied between, 20-45 minutes, 30 minutes, ≥20 minutes or ≥30 minutes. Two studies reported criteria of the heart rate returning to rest along with the period interval between trials. Three studies reporting following ATS guidelines and onestudy did not report on the trials performed. Many studies, (n=9), reported scoring the six-minute walk test according the maximum distance walked.

All studies standardized some form of encouragement during the walking process except for (n=3) that did not report any form of encouragement. An estimated of forty two percent (n=10) of included studies followed ATS guidelines when encouraging participants. Of included studies, 33.33% (n=8) reported encouraging participants every one minute whilst two studies encouraged participants every 30 seconds and one study encouraged participants at 1.3 minutes and 5 minutes.

All studies stratified normative reference values according to gender except for two studies that pooled the normative reference value for both genders into one weighted normative reference value. Of nine additional primary studies, three studies included participants in age ranges above 69. Across all tabulated studies, most studies included participants from the age group of fifty and upwards. Majority of studies, 33.33% (n=3), of the additional nine studies included data from developing countries.

In summary, most studies followed standardized guidelines when performing the six-minute walk test. Three of the nine additional studies contributed data reporting an adapted distance of 15m, 18m and 13.3m.

Table 2.3 Study walk test protocol and participants characteristics for six-minute time limited walking test.

Author	Included in Salbach *et al.*, 2015 (Y/N)	Country	Path distance, shape, pace	No. of trials, rest time, scoring	Encouragement intervals	Age	N	Male	Female
								Mean±SD	Mean±SD
Studies reporting on 6MWD measured over a standardized 30 m pathway									
Ajiboye et al. 2014	N	Nigeria	30 Straight Own pace	Test conducted once	Standardization of encouragement every 1 minute	21-67	422	548.9 ± 67.9	482.5 ± 59.9
Alameri,2009	Y	Saudi Arabia	30 Straight Own pace	1 trial	1 minute	Male: 28±8 Female: 30±8	238	430±48	386±46
Bourahli et al.2016	N	North African and Meditarrean countries: Algeria Tunisia Morocco Libya	30 Straight Own pace	Best of two 20-45 minutes	Standardization of encouragement every 1 minute	18-40	200	726 ± 55	634 ± 49

Table 2.3 Study walk test protocol and participants characteristics for six minute time limited walking test.

Britto et al. 2013	N	Brazil	30	Best of two 30 minutes	Standardization of encouragement every 1 minute	19-79	617	614±102	560±103
Casanova, 2011	Y	Brazil Chile Columbia Spain USA Uruguay Venezuela	30 Straight	2 trials ≥20 minutes Maximum distance	ATS	58(42.76) Pooled median(range)	444	571±90(380-782)	
Shrestha et al. 2015	N	Nepal	30 Straight Own pace	ATS Guidelines	10 minutes prior to start – ATS Guidelines	20 - 80	250	509±82	445±78
Soares,2011	Y	Brazil	30 Straight	3 trials Maximum distance	ATS	20-≥70	132	566 ± 87	538 ± 95
Steffens,2013	Y	Brazil	30 Straight Walk quickly	3 trials ≥30 minutes Maximum distance	ATS	66±7	77	NR	502±67

Table 2.3 Study walk test protocol and participants characteristics for six minute time limited walking test continued.

Suwanachaly, 2010	Y	Thailand	30 Straight	3 trials 20 min and return to resting HR Maximum distance	ATS	NR	162	635±75(489-994)	
Vaish,2013	Y	India (North)	30 Straight Own pace	1 trial	ATS	40-60	101	536±47	NR
Zou et al.2017	N	China	30 Straight Own pace	Best of two Two hours later	Standardization of encouragement every 1 minute	18-30	355	646.9 ± 47.15	607.4 ± 51.00
Zou et al.2017	N	China	30 Straight Own pace	Best of two Two hours later	Standardization of encouragement every 1 minute	18-59	643	623±52.53	578±49.85

Table 2.3 Study walk test protocol and participants characteristics for six minute time limited walking test continued.

Studies reported on distances measured over an adapted distance									
Camarri,2006	Y	Australia	45 Straight Walk as quickly as you can	3 trials 20 minutes Maximum distance	1 min	55-75	70	690±53	631±57
Gibbons,2001	Y	Canada	20 Straight Walk as quickly as you can	4 trials 30 minutes Maximum distance	30 seconds	20-40 41-60 61-80	79	20-40: 800±83 41-60: 671±56 61-80: 687±89	20-40: 699±37 41-60: 670±85 61-80: 583±53
Jenkins,2009	Y	Australia	45 Straight Walk as quickly as you can	2 trials ≥20 min and HR within 10 beats of resting value Maximum distance	1 min	64±8	48	682±73(549-900)	NR

Table 2.3 Study walk test protocol and participants characteristics for six minute time limited walking test continued.

Lusardi,2013	Y	USA	82.3 Straight Comfortable pace	1 trial	NR	60-69 70-79 80-89 (Pooled) 90- 101(Pooled)	56	60-69: 498(296-700) 70-79: 475±93(408-543) 80-89 (Pooled):328±102(291-365) 90-101(Pooled): 324±70(256-393)	60-69: 405±110(315-496) 70-79: 406±95(342-470) 80-89 (Pooled):328±102(291-365) 90-101(Pooled): 324±70(256-393)
Mosharraf-Hossain et al.2014	N	Bangladesh	13.3	NR	NR	25-55	200	487.5±51.8	413.1±80.1
Padron,2000	Y	Mexico	25 Straight Slow pace 25 straight Fast pace	1 trial for both	NR	20-29 30-39 40-49 50-59 60-69	188	20-29: 471(379) 30-39: 485(395) 40-49: 486(375) 50-59: 493(448) 60-69: 476(370) 20-29: 621(544) 30-39: 606(524) 40-49: 603(500) 50-59: 578(500) 60-69: 585(475)	20-29: 474(375) 30-39: 459(300) 40-49: 451(330) 50-59: 459(405) 60-69: 447(335) 20-29: 576(502) 30-39: 562(440) 40-49: 553(369) 50-59: 545(450) 60-69: 546(475)

Table 2.3 Study walk test protocol and participants characteristics for six minute time limited walking test continued.

Poh,2006	Y	Singapore	45 Straight	3 trials Maximum distance	ATS	NR	35	586±126(450-796)	538±82(405-650)
Rao et al.2014	N	Pakistan	18m	ATS Guidelines	ATS Guidelines Identical instructions given before and during test	15-65	296	502.35 ± 92.21	389.28 ± 74.29
Rikli,1999	Y	USA	45.7 Straight indoor or outdoor	1 trial Practice test a day prior	30 seconds	60-64 65-69 70-74 75-79 80-84 85-89 90-94	3908	60-64: 537±119 65-69: 616±84 70-74: 577±94 75-79: 560±93 80-84:508±115 85-89: 479±110 90-94: 436±130	60-64: 486±109 65-69:551±77 70-74: 519±92 75-79: 501±90 80-84: 465±104 85-89: 423±107 90-94: 390±118

Table 2.3 Study walk test protocol and participants characteristics for six minute time limited walking test continued.

Thaweewannakij,2013	Y	Thailand	20 Rectangle (6 x 4m) Walk as far as possible	1 trial Rest between trials if needed	1,3 and 5 minutes	60-69 70-79 ≥80	1030	60-69: 390±65(198-603) 70-79:368±81(104-602) ≥80:307±92(115-479)	60-69: 366±65(198-603) 70-79:322±67(144-485) ≥80: 256±92(72-515)
Tsang,2005	Y	Hong Kong	15m Straight	1 trial	ATS	21-30 31-40 41-50 51-60 61-70	542	21-30:651±105(340-840) 31-40:645±93(330-900) 41-50:623±80(465-795) 51-60:588±68(500-705) 61-70:484±90(370-566)	21-30:600±84(347-825) 31-40: 606±86(365-905) 41-50:541±67(333-769) 51-60:534±89(380-765) 61-70: 432±54(350-554)
Tveter et al. 2014	N	Norway	15m	ATS Guidelines	ATS Guidelines	18 -90	370	648 (633-663)	590(575-604)

2.7 Muscle Strength

2.7.1 Identification of studies

In this section we will describe the papers that summarize the normative reference values for the Deltoid and Quadriceps muscle groups.

2.7.2 Selection of studies

Three systematic reviews published within the past five years and describing normative reference values for either or both the Deltoid and Quadricep muscles groups were included in the review. The three reviews included the data of 11 179 participants from Northern America, Australia, and Europe. Table 2.4 summarizes information regarding the studies included selection of participants and muscle groups included in the systematic review.

Table 2.4 A Summary of Identified Studies: Muscle Strength

Systematic Review	n	Total number of participants included	Timeline of studies included	Inclusion Criteria	Exclusion Criteria	D	Q
Bohannon et al.(2011)	10	1696	1986-2008	Healthy individuals. Normative reference values obtained with a handheld dynamometer. Stratification according to gender, age, and side.	NR	Y	Y
Bohannon et al.(2018) - update	13	NR	Inception from 2017	Descriptive reference values for knee extension strength normalized against bodyweight. Stratification according to gender, age, and side.	Break Tests. Dynamometer measurement ceilings of less than 500 newtons.	N	Y
Benfica et al.(2018)	33	9483	Inception to December 2017	Determine normative reference value of muscle groups. Objective measure to obtain normative reference value.	Normative reference values of respiratory strength and facial muscles.	Y	Y

N = number of studies

D = Deltoid muscle

Q = Quadricep muscle

Y = Yes

N = No

NR = Not Reported

2.7.3 Charting of data

We will present a summary of the data describing the methodology followed by the three systematic reviews.

2.7.3.1 Search strategies used in the review

(Bohannon, 2011) accessed the most electronic databases initially when reporting normative reference values and at a later stage only accessed Pubmed and a handsearch, to produce a meta-analysis. (Benfica et al., 2018) accessed a limited number of databases, making use of LILACS and SciELO to account for Spanish and Portuguese articles not found in MEDLINE. Science citation index concluded to be the most uncommonly used database amongst the three authors.

2.7.4 Collating, summarising and analysing

2.7.4.1 Methodological Quality Appraisal of Systematic Reviews

According to the accompanying confidence rating scheme of the AMSTAR-2 tool, the confidence in the three systematic reviews had been assessed as "critically low" (Table 2.5). The systematic reviews showed poor compliance to the tool and had more than one critical flaw over the seven critical domains with or without non-critical domain weaknesses, thus being considered as "critically low" confidence in the quality of the systematic reviews. The 16-item AMSTAR-2 instrument is attached in (Addendum H).

Benfica *et al.*,(2018) was the only systematic review that stated that the methodology had been conducted prior to the review and accounted for deviations from the protocol. Benfica *et al.*,(2018) scored "Partial yes" to a comprehensive literature search, whilst the other authors did not meet this criterion as they either did not justify a language restriction or only restricted the search to one database. Although all three systematic reviews reported the rationale for excluding studies, specifically excluded studies had not been listed. Risk of Bias had been assessed by (Benfica *et al.*, 2018), according to the Quality Assessment of Diagnostic Accuracy Studies Tool (QUADAS-2) and no evidence of the risk of bias related influence of studies on final results of each review had been reported. Two of the systematic reviews conducted meta-analysis' due to heterogeneity of the included studies whilst (Bohannon, 2011) had not. No investigation of publication bias had been performed by the included systematic reviews.

Benfica et al.,(2018) and Bohannon.,(2018) performed a meta-analysis and reported normative reference values according to respective age groups. Benfica et al.,(2018) was found to be the only systematic review that reported following a guideline, that being the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) tool. Benfica et al.,(2018) analyzed data according to mean and standard deviation whilst (Bohannon, 2018) analyzed data according to mean and standard error due to heterogeneity identified in outcomes of the meta-analysis.

Table 2.5 16-item AMSTAR-2 Instrument: Muscle Strength

16- item criteria	**Bohannon et al.(2011)**	**Bohannon et al.(2018) - update**	**Benfica et al.(2018)**
1. Did the research questions and inclusion criteria for the review include the components of PICO?	Yes	Yes	Yes
2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?	No	No	Yes
3. Did the review authors explain their selection of the study designs for inclusion in the review?	No	No	No
4. Did the review authors use a comprehensive literature search strategy?	No	No	Partial yes
5. Did the review authors perform study selection in duplicate?	No	No	Yes
6. Did the review authors perform data extraction in duplicate?	No	No	No
7. Did the review authors provide a list of excluded studies and justify the exclusions?	No	No	No
8. Did the review authors describe the included studies in adequate detail?	Partial Yes	Partial Yes	Partial yes
9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?	No	No	Yes
10. Did the review authors report on the sources of funding for the studies included in the review?	No	No	No
11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?	No Meta-analysis conducted	Yes	Yes

12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	No Meta-analysis conducted	No	Yes
13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?	No	No	Yes
14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?	No	Yes	Yes
15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	No	No	No
16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	No	No	No

Critical Domains in Bold and include item 2,4,7,9,11,13 and 15.

2.7.4.2 Geographical Distribution and Demographics

The geographical distribution of the articles included in the three systematic reviews were categorized at country level into developed economies, developing economies and least developed economies according to the World Economic situations and prospects (WESP) 2019 guideline .All studies were conducted in developed economies across three continents as illustrated in (Figure 2.6). No studies included in the reviews were conducted in Asia, Africa, or South America.

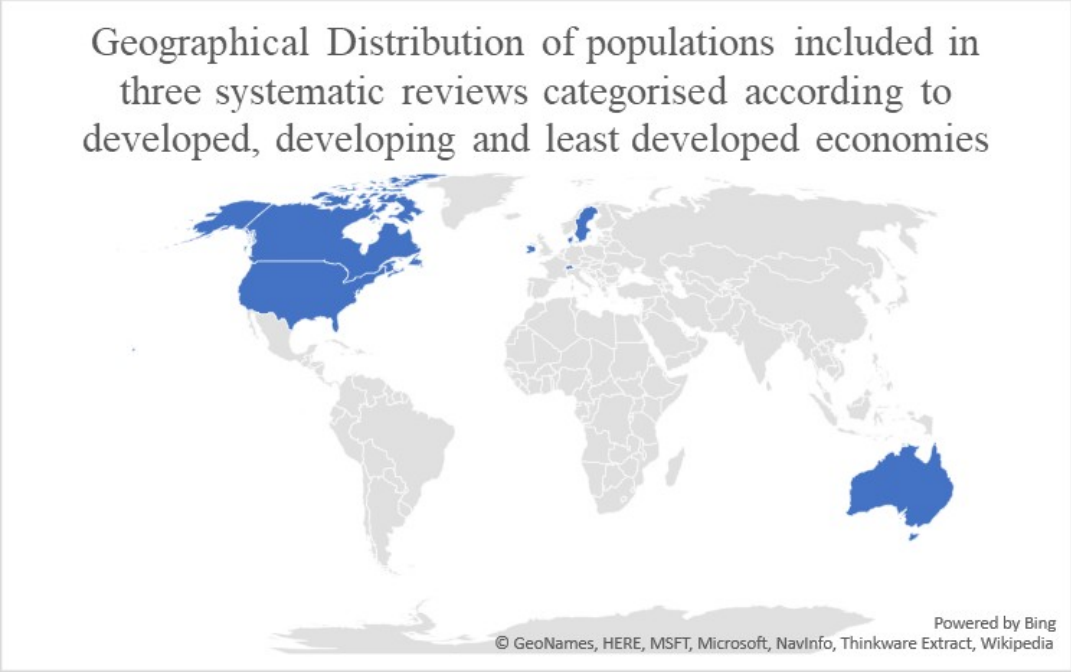

Figure 2.6 Geographical distribution of populations: Muscle Strength

All three systematic reviews included data from male and female subjects .Bohannon,(2018) and (Benfica et al., 2018) reported normative reference value data according to age groups whilst (Bohannon, 2011) reported varying ranges of ages from 3.5-89 as detailed in (Table 2.6). All participants were either regarded as ‘healthy’ or ‘apparently healthy’ in the included studies.

Table 2.6 Demographics of three systematic reviews

Study	Sex	Age range	Health status reported as:
Bohhanon et al.(2011)	Male and Female	3.5-89 across studies Not reported as age groups	Apparently Healthy
Bohhanon et al.(2018) updated	Male and Female	60-69 70-79	Apparently Healthy older adults
Benfica et.al (2018)	Male and Female	50-59 60-69 70-79	Healthy

2.7.4.3 Procedures and positioning used to assess muscle strength

Benfica et al,(2018) reported the procedure and positioning of the assessment of the Deltoid muscle strength of the three systematic reviews. Benfica et al,(2018) reported the procedure and positioning of assessing quadricep muscle strength whilst(Bohannon,(2018) reported only the positioning. Benfica et al,(2018) reported consistency in testing procedures when assessing both the deltoid and quadricep muscles however differed in positioning. Benfica et al,(2018) and Bohannon,(2018) reported similarities in positioning and make tests however, Benfica et al, (2018) reported stabilisation of the shoulders by an assistant in addition to the positioning.

All three systematic reviews reported studies that made use of hand-held dynamometers, however the hand-held dynamometers varied in type and brand. All three authors made use of either a break test or make test. Across twoauthors, commonly used dynamometers included the hand-held electronic dynamometer (Chatillon), Hand-held dynamometer (Penny and Giles), Hand-held dynamometer (CIT), Hand-helddynamometer (Ametek digital) to assess Deltoid strength. Discrepancies between these similarities developed with the type of test used. The Chatillon and Ametek digital dynamometers only performed make tests ,whilst the CIT and Penny and Giles dynamometers were used for both make and break tests across the two studies. Bohannon,(2011) reported studies performing both make and break tests whilst (Benfica et al., 2018) reported studies performing only the make test. Bohannon,(2018) did not assess deltoid strength. Other than hand-held dynamometers, only Benfica et al,(2018) reported using alternative instrumentation such as Lido Active, Quantitative muscle assessment system, Hand-held pull gauge, Electromechanical force transducer and U- shaped deflection-beam force gauges.

All three systematic reviews reported studies that made use of hand-held dynamometers, however varying in type and brand. All three authors made use of either the break or make test when accessing quadricep strength. (Benfica et al., 2018) and (Bohannon, 2011) reported studies using common dynamometers such as the hand-held electronic dynamometer (Chatillon), hand-held dynamometer (CIT) and hand-held dynamometer (Ametek digital). The hand-held electronic dynamometer (Chatillon) and Hand-held dynamometer (Amtek) were both used to perform make tests across the two reviews, whilst the Hand-held dynamometer (CIT) performed both make and break tests across the two studies. Similarly, to the assessment of the deltoid muscle, Benfica et al., (2018) reported studies only performing make tests and Bohannon, (2011) reported studies performing make and break tests, whilst Bohannon, (2018) reported studies performing a make test when assessing quadricep strength in the elderly.

It is possible that (Benfica et al., 2018) and (Bohannon, 2018) may have considered the recommendation of (Bohannon, 2011), that break tests values for 'healthy' quadriceps were far less than expected which may be attributed to inadequate tester strength and low measurement ceiling of the dynamometer to overcome a force generated by the muscle thus deciding to only perform make tests. Bohannon, (2018) described the dynamometer being used as a digital hand dynamometer with no specificity to brand and type. Other than Hand-held dynamometers, only (Benfica et al., 2018) reported using alternative instrumentation such as the Lido Active, Quantitative muscle assessment system, Hand-held pull gauge, Interface SM-250 electronic strain gauge and Pressure transducer. Tabulated details of the procedure, positioning, instruments used, and type of test (make vs break) isattached in (Addendum N) and (Addendum O).

2.7.4.4 Summary of muscle strength measured

Two of the three included systematic reviews reported normative reference values. Bohannon, (2011) reported literature informing the various procedures, positioning and tools used to measure muscle strength. Since Bohannon, (2018) had been an update including a meta-analysis of Bohannon,(2011), it was decided to include Bohannon,(2011) to inform any possible changes in the methodology of testing and resultant effects on the normative reference values. Benfica et al,(2018) reference values for muscle strength were illustrated separately for the Deltoid and Quadricep muscle groups across three age groups according to mean and standard deviation. Bohannon, (2018) reference values were measured only for the Quadricep muscle group across two age groups, represented by mean and standard measure of error and thus illustrated separately.

2.7.4.4.1 Deltoid Strength

(Benfica et al., 2018) reported reference values (mean/SD) for Deltoid strength in the age group (50-59) and (60-69) which illustrated that the dominant upper limb is stronger than the non-dominant upper limb in both male and female groups. In both of the aforementioned age groups, reference values indicated that males (dominant and non-dominant) are stronger than females (dominant and non- dominant). Similarly, in the age group (70-80), the dominant upper limb is stronger than the non- dominant upper limb in the male group. In contrast the female group indicated that the non- dominant upper limb (105.46±21.05) as stronger than the dominant upper limb (101.95±21.89).
Male groups achieved significantly greater newtons of force compared to the female group across all three age groups. A trend of declination is observed across the age groups indicating that as age increases, strength in the deltoid muscle group (non-dominant and dominant) decreases.

2.7.4.4.2 Quadricep Strength

Benfica et al,(2018) reported reference values (mean/SD) for Quadricep strength, illustrating that upper limb (dominant and non-dominant) in the male groups are stronger in comparison to the upper limb (dominant and non-dominant) in the female group across all three age groups. The dominant upper limb shows indication of being stronger than the non-dominant upper limb in both male and female groups across all age group with two exceptions. The first being the age group 60-69 whereby the male group illustrated the non-dominant upper limb (377.57±67.75) as being stronger the dominant upper limb (372.71±81.81).

Similarly, the second occurring in the age group 70-80 in the male group, which illustrated the non-dominant upper limb (365.0±71.21) as being stronger than the dominant upper limb (358.57±76.13). A trend of declination is observed across the age groups indicating that as age increases, strength in the Quadricep muscle group (non-dominant and dominant) decreases.

Bohannon,(2018) developed reference values for Quadricep strength across the age group (60-69) and (70-80) as displayed graphically in (figure 9.3.4.2.2). Reference values were reported as mean and standard measure of error and thus displayed separately. Male groups (dominant and non-dominant) were stronger in comparison to female groups (dominant and non-dominant) across both age groups. In the (60-69) group the male groups reported stronger non-dominant upper limb strength (48.8) than the dominant upper limb (48.0). A similar pattern was observed inthe 70-80 age group where the male group reported stronger non-dominant upper limb strength (48.1) than the dominant upper limb (46.1). A trend of declination is observed across the age groups indicating that as age increases, strength in the Quadricep muscle group (non-dominant and dominant) decreases in females. The male group displayed a plateau with minimal inclination/declination of age relative to muscle strength taking into consideration the increasing strength of the non-dominant upper limb.

2.8 Maximal Inspiratory Pressure

2.8.1 Identification of studies

One systematic review was identified through a primary search. One additional study was identified through a secondary search as the systematic review was published more than five years ago. Table 2.7 details the two identified studies. The search strategy and list of databases accessed during the primary search is available in (Addendum K) and the search strategy and list of databases accessed during the secondary search is available in (Addendum L).

Table 2.7 A Summary of identified studies: Maximal Inspiratory Pressure

Systematic Review	Number of studies included	Total number of participants included	Timeline of studies included	Inclusion Criteria	Exclusion Criteria	Age Range
Pessoa et al.(2014)	22	9723	1964-2011	Healthy adults > 18 years of age. Purpose of study: Determine reference values of Maximal Inspiratory pressure. Studies published in English and/or Portuguese.	Review article, thesis, or dissertation. Measurement assessed in standing rather than sitting.	18-29 30-39 40-49 50-59 60-69 70-83

Table 2.7 A Summary of identified studies: Maximal Inspiratory Pressure continued

Additional Studies						
Pessoa et al.(2014)	NR	134	2014	Healthy adults between 20-89. Spirometric parameters within limits for Brazilian population. Normal Body Mass Index (BMI) (18.5 Kg/m2≤BMI≤29 .9 Kg/m2)	History of smoking. Risk of occupational environment. History of neuromuscular, respiratory or heart disease. History of cognitive impairment. Fever/cold/sinus infection in the last three weeks. Use of drugs/muscle relaxants. Exhaustive exercises 48 hours prior. Upper limb pain. Inability to understand procedures. Test interrupted by muscular/respiratory discomfort. Saturation, Blood pressure and Heart rate within normal ranges.	20-29 30-39 40-49 50-59 >60

'NR' = Not Reported

2.8.2 Selection of studies

Studies was included according to criteria illustrated in (Table 2.1). A selection process was followed to identify relevant studies at title level, abstract level and full-text level. Any studies that were duplicated, non-English, reference values that were not normative, normative reference values of children, published more than five years ago and research reports and protocols were excluded. The specific selection process is illustrated in (Figure 2.7). The selection flow process for the secondary search is available in (Addendum M).

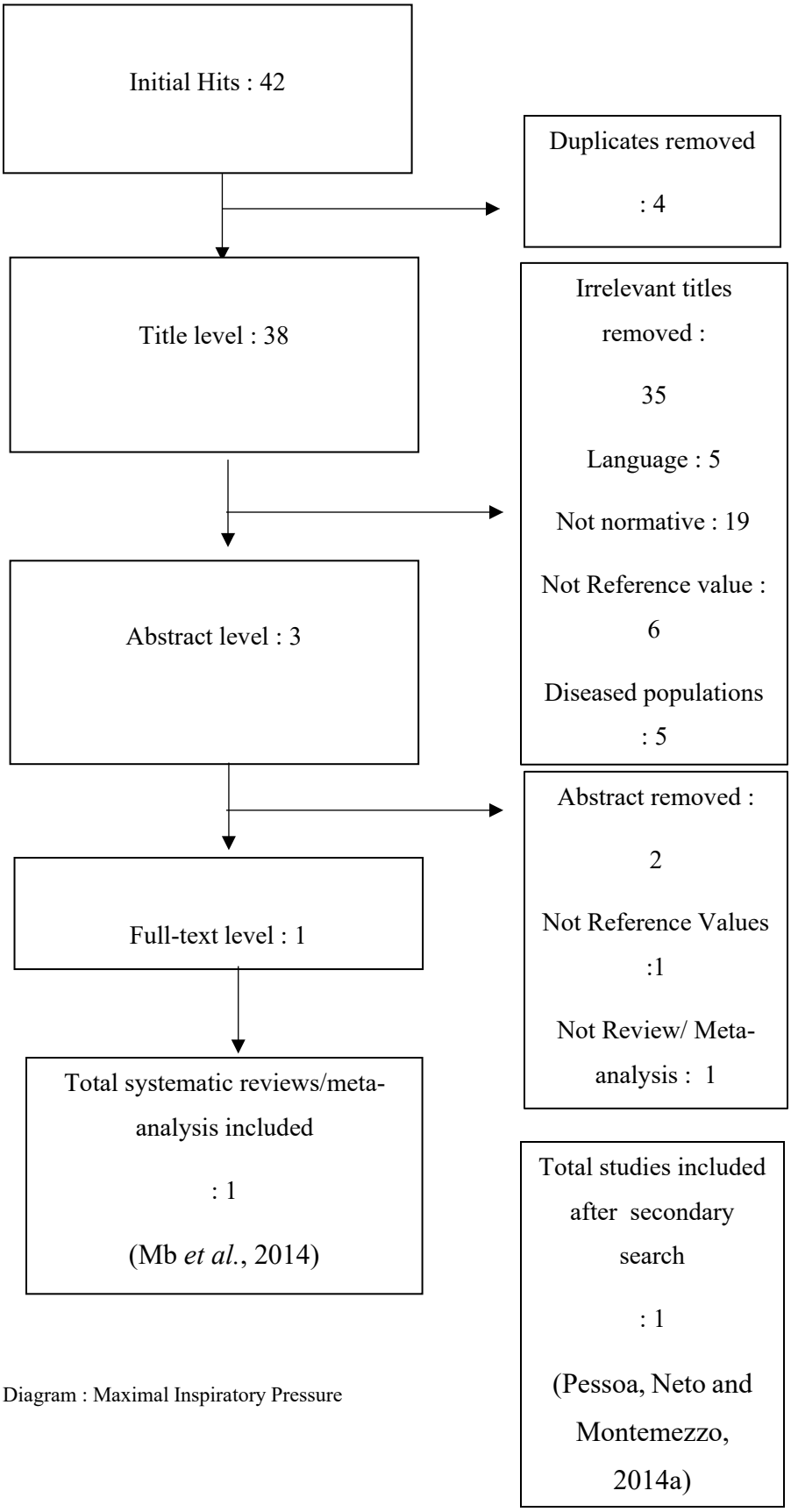

Figure 2.7 Selection Process Flow Diagram : Maximal Inspiratory Pressure

2.8.3 Charting of data

We will present a summary of the data describing the methodology followed by the systematic review and one additional study.

2.8.3.1 Search strategies used.

(Mb *et al.*, 2014) accessed the following databases: MEDLINE, CINAHL, SportsDiscus database, EMBASE and Cochrane. Key words used in the search strategy included “respiratory muscles” combined with “maximal inspiratory pressure” and “reference values”. It is a possibility that (Mb *et al.*, 2014) did not include the additional study as the author only limited their search to the five databases.

2.8.4 Collating, summarizing and reporting

2.8.4.1 Methodological appraisal of Systematic Review

Descriptive statistics of reference values was extracted from the results sections of (Mb *et al.*, 2014). The included study is quantitative in design with a clear data analysis method adding credibility to our results.

According to the accompanying confidence rating scheme of the AMSTAR-2 tool, the confidence of the systematic reviews had been assessed as “critically low”. The systematic reviews showed poor compliance to the tool and had more than one critical flaw over the seven critical domains with or without non-critical domain weaknesses thus being considered as “critically low” confidence in the quality of the systematic reviews (Table 2.8). Item 2 on the criteria was the only item that was scored as ‘partial yes’ as the literature search strategy used by the authors did not consider searching reference lists, study registries, grey literature, consult experts in the field and conduct a search within 24 months of completion of the review. The Quality Assessment of Diagnostic Accuracy of studies (QUADAS) tool was used to assess the methodological quality of the studies included in the systematic review. Both the systematic review and one additional study reported normative reference values according to mean and standard deviation.

Table 2.8 16-item AMSTAR-2 Instrument.: Maximal Inspiratory Pressure

16- item criteria	**(Mb *et al.*, 2014)**
1. Did the research questions and inclusion criteria for the review include the components of PICO?	Yes
2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?	No
3. Did the review authors explain their selection of the study designs for inclusion in the review?	No
4. Did the review authors use a comprehensive literature search strategy?	Partial Yes
5. Did the review authors perform study selection in duplicate?	Yes
6. Did the review authors perform data extraction in duplicate?	Yes
7. Did the review authors provide a list of excluded studies and justify the exclusions?	No
8. Did the review authors describe the included studies in adequate detail?	Yes
9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?	Yes
10. Did the review authors report on the sources of funding for the studies included in the review?	No
11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?	Yes
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	Yes
13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?	Yes
14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?	Yes
15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	No
16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	Yes

2.8.4.2 Methodological appraisal of one additional study.

The one study appraised by the McMaster Critical review form achieved a scoring of 9 out of 15 or 60% (Table 2.9). The study is of a cross-sectional study design; however, this was not explicitly reported in the study. Under 4a) and 4b), the sample size of 134 participants has been justified statistically and the sample described in detail. The sample comprised of male and female volunteers between the ages of 20-89 years. There is a possibility that the sample may be of convenience as participants volunteered if they considered themselves healthy thus making the group of participants potentially biased. The reliability and validity of the outcomes measured in the study showed no evidence of being assessed and thus scored as 'not addressed' in the critical review form. Intervention or the method in which the maximal inspiratory pressure (MIP) was assessed in Pessoa, Neto and Montemezzo,(2014) was explained with sufficient detail. No evidence of reporting the avoidance of cointervention was reported in the study. The number of participants was reported explicitly in the study with no evidence of reporting of participants dropping out of the study. It is important to note that not reporting any dropouts affects our confidence in the results of the study and the possibility that the results may not truly reflect the participants of the study.

Table 2.9 McMaster Critical review of one additional study

Study	**Items Checklist on McMaster Critical review form**														**Score**
	1	**2**	**3**	**4a**	**4b**	**5a**	**5b**	**6a**	**6b**	**6c**	**7a**	**7b**	**7c**	**7d**	**8**	
(Pessoa, Neto and Montemezzo, 2014a)	Y	Y	Cross sectional study	Y	Y	NA	NA	Y	Y	NA	N	Y	Y	N	Y	9/15

'Y' = Yes

'N' = No

'NA' = Not Addressed

2.8.4.3 Geographical Distribution and Demographics

The geographical distribution of the studies was categorised at economy level into developed, developing and least developed economies according to the World Economic situations and prospects (WESP) 2019 guideline (Figure 2.8). The systematic review included mostly developed economies except for India and Brazil. The additional study only included a developing economy from Brazil. No populations had been included in Africa, Europe, and Australia. Both the systematic review and additional study included male and female participants that were considered as 'Healthy' according to criteria.

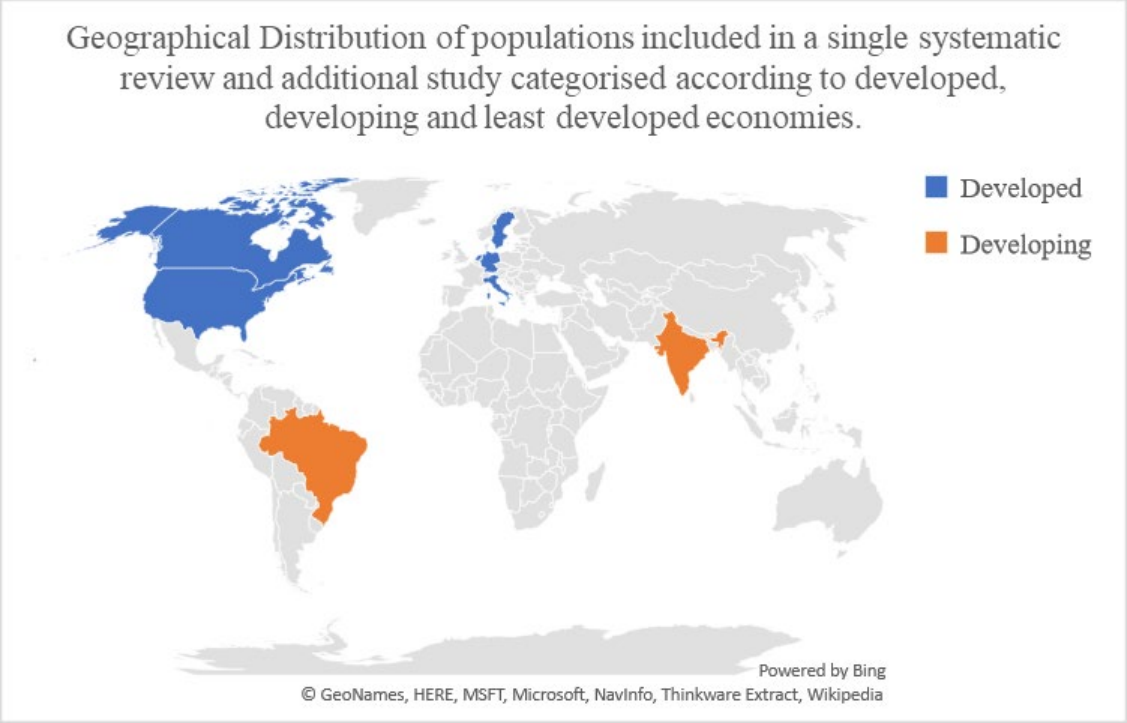

Figure 2.8 : Geographical Distribution of populations : Maximal Inspiratory Pressure

2.8.4.4 Summary of Method used to assess Maximal Inspiratory Pressure

Maximal Inspiratory pressure (MIP) measures the strength that the inspiratory muscles are able to generate in a single maximal effort (Caruso *et al.*, 2015). The inspiratory muscles that develop the inspiratory pressure comprise of the diaphragm muscle, ribcage muscles and abdominal muscles (Aliverti, 2016). Deteriorating or poor respiratory muscle strength had said to have been linked to poor physical function outcomes and chronic respiratory diseases (Guerra, Id and Maria, 2018). It isimportant that such a clinical field test requires standardisation to ensure accuracy of the measured outcome of an individual's respiratory muscle strength. It is possible that a discrepancy exists amongst different populations in the assessment of MIP and is necessary to explore as it affects the accuracy of the outcome and thus the normative reference value for maximal inspiratory pressure.

2.8.4.4.1 Devices and tools used to assess Maximal Inspiratory pressure

Pessoa, Neto and Montemezzo, (2014) reported using a Digital Manometer (NEPEB-LabCare/UFMG) with pressures measured with pressure transducer to assess MIP, calibrated every six months, whilst (Mb *et al.*, 2014) did not report the devices used to generate MIP in their included studies, however both studies measured pressure in "cmH_20" and made use of a mouthpiece for their device. Pessoa, Neto and Montemezzo,(2014) made use of a diver's type mouthpiece with a 2mm leak and nose clip. In contrast, Mb *et al.*,(2014) reported that included studies used a tube, flanged, facemask as a mouthpiece or otherwise did not report using a mouthpiece. Guerra, Id and Maria, (2018) found that the number of times a MIP maneuver is performed is less due to the difficulty when fitting the mouthpiece especially when assessing the elderly population and suggested that the sniff test may be a viable option to add information regarding the participants MIP. The systematic review reported not using a nose clip in any of their included studies. Similarly, the leak size of devices included in the systematic review reported using a 2mm leak whilst other studies reported leak sizes of 1.27mm ,1.06mm, 1mm, 0.90mm ,0.6mm or otherwise the study included in the systematic review did not report the leak size.

2.8.4.4.2 Procedure, positioning and criterion for stopping

The procedure, positioning, starting volume, time of maximal inspiratory pressure, trials and criteria for stopping was identified in both the systematic review and additional study. (Mb *et al.*, 2014) did not report the procedure and positioning followed by included studies and reported as a limitation that ATS guidelines and ERS guidelines was not followed. In contrast, Pessoa, Neto and Montemezzo,(2014) reported that instructions and a demo of the technique had been given prior to testing and a standard command ofencouragement had been given and reported a lack of standardizing procedures. Pessoa, Neto and Montemezzo,(2014) instructed participants to be seated with their legs and trunk supported as a starting position. Both studies similarly generated a maximal inspiratory pressure, after exhaling, at residual volume. The time of in which the MIP was generated commonly between the two studies was of 1.5 seconds. (Mb *et al.*, 2014) reported studies in which the MIP was generated in 1 second, about 1 second, minimum of 2 seconds, 2 seconds or without control. Pessoa, Neto and Montemezzo,(2014) reported that 5 trials was carried out with 1 minute intervals between each trials similar to (Mb *et al.*, 2014), that reported studied that performed a minimum or maximum of 5trials with no evidence resting intervals reported. The systematic review also reported that included studies performed 3-7 trials, maximum of 3 trials, mimimum of 3 trials, minimum of 4 trials, maximum of 7 trials and some studies did not specify.

The criteria used to stop the MIP assessment after completing trials differed between the systematic review and additional study. (Mb *et al.*, 2014) reported studies recording the highest of two identical values, highest of two values with a 5% difference, highest of two values with 10% difference, highest of three trials with similar readings, highest of three values within 5% difference, highest value of < 10% of three trials, highest value of < 10% of all trials and highest value varying 5%. Pessoa, Neto and Montemezzo,(2014) stopped assessing the MIP of the participant when three reproducible tests were produced, with variation less than or equal to 10% or variation not more than 20% if the generated MIP was a larger value. It is necessary to note that both studies repeated tests as a learning effect is potentially present as the assessment depends on the amount of effort the participant generates and thus the highest value is always taken (Guerra, Id and Maria, 2018). A summary tabulated in (Addendum P), details the procedure, positioning, and criteria for stopping used.

2.9 Grip Strength

In this section, we will summarize normative reference values for grip strength retrieved from five systematic reviews. The retrieved evidence was recently published and therefore a secondary search was not further conducted.

2.9.1 Identification of studies

Five systematic reviews and Meta-analysis was retrieved. One systematic review updated their study to consolidated normative reference values for a specific age group using a meta-analysis. The identified studies are illustrated in (Table 2.10). The search strategy used to identify the studies is available in (Table 2.1). A list of the databases accessed during the search is available in (Addendum K)

Table 2.10 A Summary of identified studies: Grip strength

Systematic Review	Number of studies included	Total number of participants included	Timeline of studies included	Inclusion Criteria	Exclusion Criteria	Age Range
(Bohannon, Peolsson, Massy-westropp, Desrosiers, *et al.*, 2006)	12	3317	1982-2004	Jamar Dynamometer used in the second handle position. Consistency with the ASHT recommendations (shoulder abduction; elbow flexed to 90 degrees; neutral forearm) Summary data was presented separately for Male and Female, Left and Right sides. Subjects need to be in one of the 12 age groups.	Not Reported	20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75+
(Bohannon, Peolsson, Massy-westropp, Desrosiers, *et al.*, 2006) updated	7	1849	1982-2004	Jamar Dynamometer used in the second handle position. Consistency with the ASHT recommendations (shoulder abduction; elbow flexed to 90 degrees; neutral forearm) Summary data was presented separately for Male and Female, Left and Right sides. Subjects need to be in one of the three age groups. (20-29,30-39,40-49)	Not Reported	20-29 30-39 40-49

Table 2.10 A Summary of identified studies: Grip strength continued

(Dodds et al., 2014)	63	498 (225,1119) Median (IQR)	1980-2014	Published studies from 1980 until 2014 reporting normative data. Studies included based on samples of the general population.	Sample of the population excluded based on occupational and illness groups.	Child/adolescent ≤18 years Adults all <50 years Adults all ≥50 years Adult, both ages All stages above
(Kamide *et al.*, 2015)	33	15784	1983-2014	Papers written in Japanese or English. Papers on Japanese community-dwelling people aged ≥ 60 years old. Papers on community-dwelling elderly independent in activities of daily living (ADLs). Papers not examining frail elderly or elderly with an evident disease. Papers reporting measurements in kilograms or Newtons. Papers reporting data on handgrip strength by sex Papers listing the number of subjects and the mean and standard deviation.	Not Reported	Presented as mean age. 67.0-79.8
Benfica et.al (2018)	2	218	1985 and 2008	Studies determining normative reference values of two or more appendicular and/or axial muscle groups. Healthy individuals at any age. Use of any equipment or method to measure strength.	Studies that reported normative reference values for facial or respiratory muscles.	65-69 70-74

2.9.2 Selection of studies

A selection process was followed to identify relevant studies at title level, abstract level and full-text level. Any studies that were duplicated, non-English, reference values that were not normative, normative reference values of children, published more than five years and research reports and protocols were excluded. (Figure 2.9) illustrates the subject specific process followed to result in five systematic reviews.

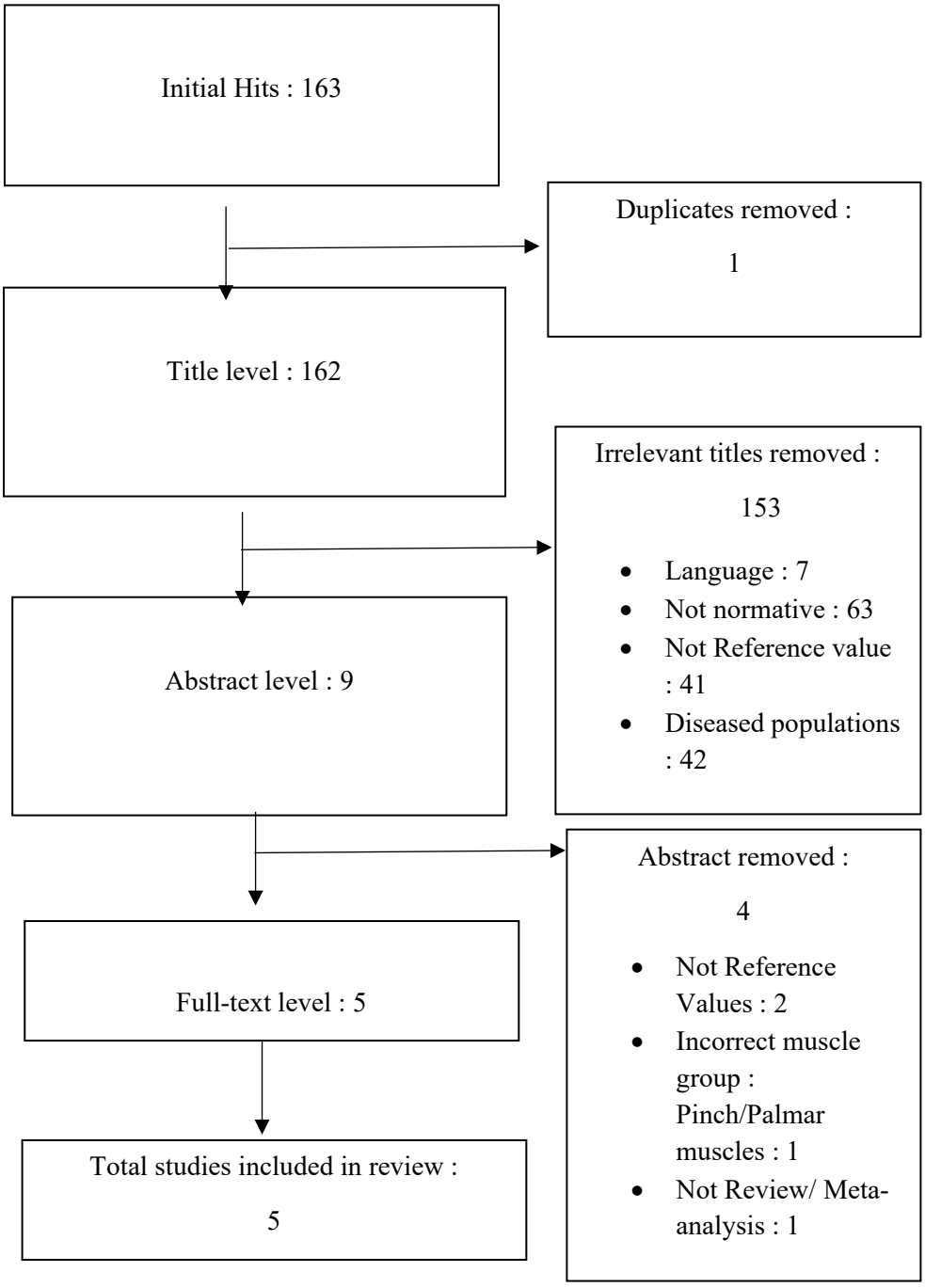

Figure 2.9 Selection Process Flow Diagram : Grip Strength

n = Number of included studies.

2.9.3 Charting of data

We extracted the data from the five systematic reviews. A summary of the methodology quality, geographical distribution and normative reference values will be presented.

2.9.3.1 Databases accessed Search strategies used.

Similar search terms were combined in different search strings across all five systematic reviews .(Kamide *et al.*, 2015) added translated search terms of the English terms to include any studies pertaining to the Japanese population.

Six databases were included by the five systematic reviews. Most systematic reviews accessed EMBASE, MEDLINE and CINAHL. Kamide *et al*,(2015) was the only study that accessed the Pubmed electronic database.(Benfica *et al.*, 2018) accessed SciELO and LILACS to possibly account for Spanish and Portuguese articles not found in MEDLINE. None of the reviews included Science Direct, Scopus, or Web of Science in their search strategy. Hand searching of published journals was also not done.

2.9.4 Collating, summarizing and reporting

2.9.4.1 Methodological appraisal of Systematic Reviews

According to the accompanying confidence rating scheme of the AMSTAR-2 tool, the confidence in the five systematic reviews had been assessed as “critically low”. The systematic reviews showed poor compliance to the tool. This could be due to the PRISMA tool only being developed in 2009 thus causing poor adherence as the AMSTAR-2 tool was only developed in 2007. The systematic reviews had more than one critical flaw over the seven critical domains (in bold) with or without non-criticaldomain weaknesses thus being considered as “critically low” confidence in the quality of the systematic reviews(Table 2.11). The three main methodological quality issues identified are namely, 1) lack of reporting a comprehensive search process including both search for studies as well as selecting studies and extracting data in duplicate. 2) indication of following a protocol was not clearly reported as well as the study designs for inclusion. 3) risk of bias was not assessed for each individual study for all systematic reviews except one systematic review. These three issues identified greatly affects our judgment in the results extracted and further supports the “critically low confidence” that we have in their results.

The five reviews were published between 2006 to 2018. Bohannon, Peolsson, Massy-westropp, Consultants, *et al.*,(2006) published a meta-analysis synthesizing normative reference values for the age group (20-49) years based on the initial systematic review and meta-analysis published in 2006 that included participants over age groups (20-75+). Dodds et al,(2014) included the most number of articles in a meta-analysis (n=63), whilst (Benfica *et al.*, 2018) included the least amount of articles in a meta-analysis (n=2). All five systematic reviews reported having synthesised data into a Meta-analysis. Dodds et al., 2016 and Benfica *et al.*,(2018) adhered to PRISMA guidelines. Normative reference values were reported according to mean and standard deviation across most studies. Dodds et al.,(2016) reported normative reference values as pooled z-scores (95% CI) and Kamide *et al*,(2015) reported normative reference values as weighted means (95% CI).

All included systematic reviews scored “Partial Yes” to critical item four on the 16 item criteria except for (Lifecourse, Unit and Medicine, 2014) that scored as “no”. This is an indication of the lack of a comprehensive search across all five studies. Similarly, it has been assessed that all but one systematic review did not select their studies and extract their data in duplicate. Thus, further supporting the “critically low” confidence that we may have in the methodological quality of the reviews.

Two studies provided adequate detail of the studies included in their systematic review while one study scored "Partial Yes" and two studies have been assessed as not including adequate detail of their studies. Consistently over all five systematic reviews, no list was provided for the studies excluded. All studies only provided the number of studies excluded and a summary of possible reasons as to why they have been excluded. The assessment of risk of bias of studies was only reported by (Benfica *et al.*, 2018). Benfica *et al*,(2018) used the Quality Assessment of Diagnostic Accuracy Studies Tool (QUADAS-2) and one review reported the risk of bias related influence of individual studies on results of each review. The other three studies reported homogenous results.

Lastly, (n=2) studies reported the use of funding for completion of their studies and no investigation of publication bias was apparent in all five systematic reviews. It is possible that the funding source intended on publishing in journals most favorable to them. The fact that it was not investigated further affects their credibility.

Table 2.11 16-item AMSTAR-2 Instrument : Grip Strength

16- item criteria	**(Bohannon, Peolsson, Massy-westropp, Desrosiers, *et al.*, 2006)**	**(Bohannon, Peolsson, Massy-westropp, Desrosiers, *et al.*, 2006) updated**	**(Dodds et al., 2014)**	**(Kamide *et al.*, 2015)**	**Benfica et al.(2018)**
1. Did the research questions and inclusion criteria for the review i nclude the components of PICO?	No	Yes	Yes	Yes	Yes
2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?	No	No	No	No	Yes
3. Did the review authors explain their selection of the study designs for inclusion in the review?	No	No	No	No	No
4. Did the review authors use a comprehensive literature search strategy?	Partial Yes	Partial Yes	No	Partial Yes	Partial yes
5. Did the review authors perform study selection in duplicate?	No	No	No	No	Yes
6. Did the review authors perform data extraction in duplicate?	No	No	No	No	No
7. Did the review authors provide a list of excluded studies and justify the exclusions?	No	No	No	No	No
8. Did the review authors describe the included studies in adequate detail?	No	Yes	Yes	No	Partial yes
9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?	No	No	No	No	Yes
10. Did the review authors report on the sources of funding for the studies included in the review?	No	No	Yes	Yes	No
11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?	No	Yes	Yes	No	Yes
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	No	No	No	No	Yes
13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?	No	No	No	No	Yes

14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?	No	Yes	Yes	No	Yes
15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	No	No	No	No	No
16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	No	No	Yes	Yes	No

Critical Domains in Bold and include item 2,4,7,9,11,13 and 15.

2.9.4.2 Geographical distribution and demographics

The geographical distribution of the studies was categorised at economy level into developed, developing and least developed economies according to the World Economic situations and prospects (WESP) 2019 guideline. No populations from "least developed" economies were included. All five systematic reviews included male and female participants that were considered as 'healthy' according to criteria. Figure 2.10, illustrates the overall geographical distribution of the populations included in all five systematic reviews according to developed and developing economies.

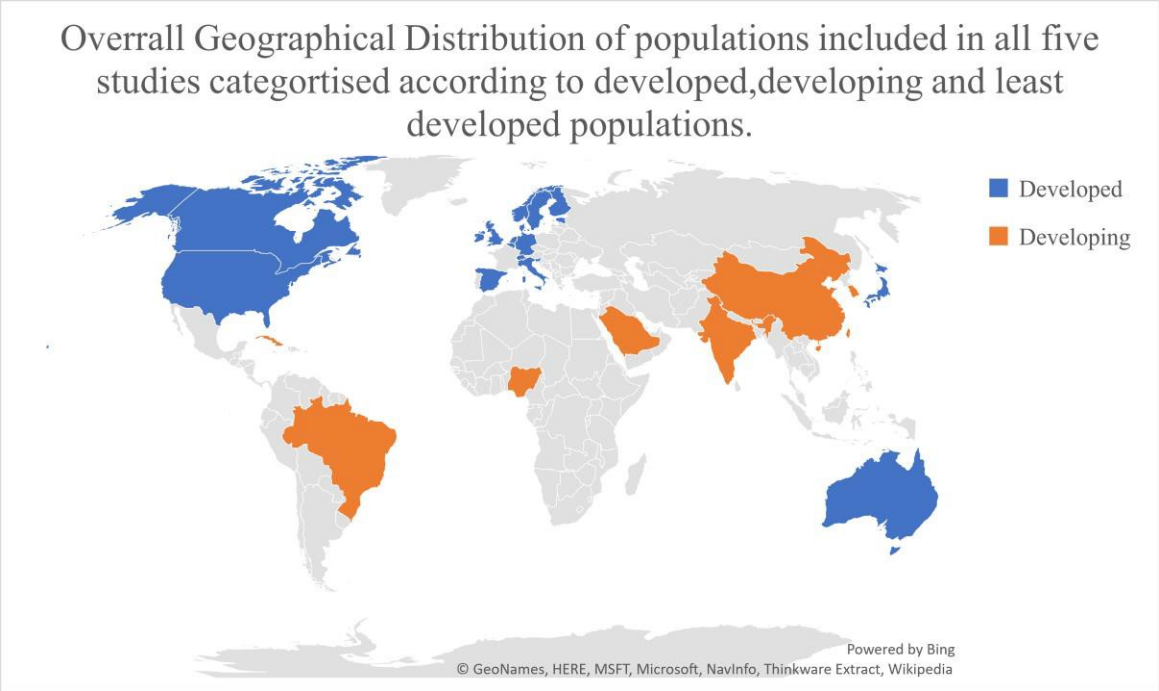

Figure 2.10: Geographical distribution of the populations: Grip Strength

2.9.4.3 Summary of grip strength normative reference values

All five systematic reviews provided descriptive statistics for grip strength normative reference values. Two of the five included reviews reported a pooled z-score and weighted mean with 95% confidence interval (Table 2.12).

The normative reference values of the other three systematic reviews are illustrated in a (Table 2.13). We have decided to illustrate a summary of these normative reference values together as the second systematic reviews is an update of the first systematic review with the purpose of synthesising normative reference values for the (20-49) age groups.

Dodds et al,(2014) reported a pooled z-score of -1.34 (-1.57,-1.11) for the developing region of Africa, thus portraying that these populations are scored more than 1 Standard Deviation (SD) lower than the mean. Dodds et al,(2014) compared normative references of developing and developed regions to their British " reference standard" to identify whether their cut off points are usable in other settings. In this way, it has come attention that a large contrast exists between Africa and e.g.) the pooled z-scores of the developed regions except with some similarity to Australia. This gives credence to the idea that different populations are different to developing economies. Kamide *et al*,(2015) reported normative reference values as a weighted mean with a 95% confidence interval. Unfortunately, the weighted normative reference value has a great limitation in describing the role of hand dominance and grip strength. The grip strength was cumulatively described for eachgender in the elderly only above or equal to the age of 60.

Table 2.12 Summary of studies presenting grip strength reference values

Study	**Classification: Region**	**Statistical Method: Pooled z-score**	**(95% CI)**
(Dodds et al., 2014)	Overall	-0.09	(-0.14, -0.04)
	Developing Region	-0.85	(-0.94, -0.76)
	1.Africa	-1.34 SD	(-1.57, -1.11)
	2.America excluding North America	-0.80	(-0.97, -0.63)
	3.Asia excluding Japan	-0.74	(-0.86, -0.62)
	Developed Region	0.12	(0.07, 0.17)
	1.Australia	-0.01	(-0.20, 0.18)
	2.Europe	0.13	(0.07, 0.19)
	3.Japan	-0.13	(-0.40, 0.14)
	4.Northern America	0.16	(0.04, 0.28)
Kamide *et al.*, 2015)	**Classification: Gender**	**Statistical Method: Weighted Mean**	**(95% CI) Kg**
	Male	33.11	(32.27:33.96)
	Female	20.92	(20.45:21.39)

Table 2.13 Summary of studies presenting grip strength reference values

Study	Classification: Gender; Age groupand Left, Right.			Statistical Description: Mean (kg)	(95% CI)/ Standard Deviation	
					LCI	UCI
Bohannon, Peolsson, Massy-westropp, Desrosiers, et al., 2006)	20-24	Right	Male	53.3	45.2	61.5
			Female	30.6	26.7	34.4
		Left	Male	47.4	38.8	56.1
			Female	27.9	23.1	32.6
	25-29	Right	Male	53.9	44.3	63.6
			Female	33.8	29.5	38.1
		Left	Male	50	41.1	58.9
			Female	30.8	27.2	34.5
	30-34	Right	Male	52.8	44.1	61.5
			Female	33.8	28.9	38.6
		Left	Male	49.2	40.4	57.9
			Female	31.8	29	34.4
	35-39	Right	Male	53.3	44	62.6
			Female	33.2	28.6	37.8
		Left	Male	51.6	44	59.3
			Female	30.2	25.8	34.5
	40-44	Right	Male	54.1	47.1	61.2
			Female	32.8	28	37.6
		Left	Male	49.8	42.5	57.1
			Female	29.3	24.5	34
	45-49	Right	Male	50.4	42.5	58.3
			Female	33.9	28.9	39
		Left	Male	48.7	40.3	57.2
			Female	30.8	25.8	35.7
	50-54	Right	Male	50.6	44.2	56.9
			Female	30.9	26.7	35.2
		Left	Male	45.2	39.4	51.1
			Female	28.8	24	33.5

	55-59	Right	Male	44.1	36.7	51.4
			Female	29.9	26.4	33.6

Table 2.13 Summary of studies presenting grip strength reference values continued

		Left	Male	41	33.7	48.4
			Female	27.2	24.6	29.5
	60-64	Right	Male	41.7	36.8	46.7
			Female	25.9	22.2	29.6
		Left	Male	38.7	33.4	44.4
			Female	23	18.6	27.3
	65-69	Right	Male	41.7	35.4	47.9
			Female	25.6	22.5	28.8
		Left	Male	38.2	32	44.4
			Female	22.9	19.6	26.2
	70-74	Right	Male	38.2	32	44.5
			Female	24.2	20.7	27.8
		Left	Male	36.2	30.3	42.1
			Female	22.5	19.1	25.8
	75+	Right	Male	28	12.7	31
			Female	18	16	19.9
		Left	Male	29.8	24.8	34.7
			Female	16.4	14.7	18.1
(Bohannon, Peolsson, Massy-westropp, Desrosiers, *et al.*, 2006) updated	20-29	Right	Male	118.3	107.2	129.5
			Female	70.6	64.6	76.6
		Left	Male	109.8	97.9	121.7
			Female	65.8	59.7	71.8
	30-39	Right	Male	117.6	107	128.1
			Female	73.9	66.8	80.9
		Left	Male	113.7	103.5	123.9
			Female	69	64.1	74
	40-49	Right	Male	115.1	105.5	124.8
			Female	73.4	66	80.09
		Left	Male	109.5	99.6	119.3
			Female	66.2	58.9	73.5

Table 2.13 Summary of studies presenting grip strength reference values continued

Benfica et.al (2018)	65-69	Right	Male	91.3	18.5	
			Female	52.5	10.2	
		Left	Male	81.5	18.5	
			Female	46.7	10.3	
	70-74	Right	Male	79.1	20.1	
			Female	51.2	10.5	
		Left	Male	71.8	19.8	
			Female	45.3	10.8	

2.9.4.4 Summary of procedure and positioning followed

Procedure and positioning

The procedures and positioning used to obtain grip strength normative reference values differed across all five systematic reviews. The procedures followed and positioning used was extracted according to 1) whether the procedure followed was in accordance with American Society of Hand Therapists (ASHT) guidelines, 2) the procedure and positioning, 3) the type of dynamometer used, 3) the handle position of the dynamometer, 5) the unit of measure used, 6) dominance and left or right, 7) description of trials, 8) procedural limitations and 9) the use of cut off values. We will highlight the differences, similarities, and new findings across the studies briefly.

Most studies (n=4) specified that grip strength was measured in a seated position whilst Kamide *et al*,(2015) reported using the seated position as well as the standing position. Less than half of the included studies in the systematic reviews followed the ASHT guidelines. With regard to the systematic reviews that did report the positioning followed, (n=3) systematic reviews used identical positioning with the exception of (Benfica *et al.*, 2018). Theexception was that (Benfica *et al.*, 2018) went on to further report that the position of the wrist needs to be between 0 and 30 degrees extension as well as 0 and 15 degrees ulnar deviation.

Whilst all included systematic reviews commonly reported using the Jamar Hydraulic Dynamometer, two studies reported using other dynamometers. The Smedley dynamometer was used by Kamide *et al*,(2015) and Lifecourse, Unit and Medicine,(2014) reported using hydraulic, electronic and other dynamometers that was not specified. Although Benfica *et al*,(2018) did not comply to the ASHT guidelines, they also reported using the dynamometer in the second handle position. The unit of measure used across the five studies varied. It has come to our attention that Bohannon, Peolsson, Massy-westropp, Desrosiers, *et al*,(2006) presented their data according to Kilograms (Kgs) and Pounds (lbs) in their initial study. Their updated study consolidating normative reference values for a specific age group reported their unit of measure in only Pounds (lbs).

Most studies (n=3) reported categorising grip strength according to Left and Right. The remaining studies considered dominant and non-dominant hands. All studies reported a wide spectrum of trials used as criteria used to stop. Bohannon, Peolsson, Massy-westropp, Desrosiers, *et al*,(2006) and their later updated study had been the systematic reviews that reported procedural limitations. A new limitation that had been identified in the updated study was that the mean of three trials was inconsistently used across all studies.

2.10 Discussion

We have mapped and compared the populations which have contributed to normative reference values for five clinical field tests used in primary based rehabilitation. After synthesizing the data for each field test, various key components and issues will now be highlighted.

2.10.1 Muscle Strength

The synthesized data highlighted the following four issues in the reference values available for the Quadricep and Deltoid muscle groups. The issues include the limited populations represented; the lack of age and gender stratified data; the differences noted in the execution of manual muscle tests; and finally, the poor quality of the systematic reviews.

Currently data only exists for population samples from the developed economies as illustrated in (Figure 2.2). The developed economies identified included North America, Australia, and certain regions of Europe. It is possible that we need to consider the expenses, resources and interest of participants that affect normative reference values for muscle strength not being reported in developing or least developed countries

After having further investigated the demographics of the participants included across all three systematic reviews, another issue was highlighted. Selection of participants did not include stratifying for age. Two of the three systematic reviews stratified their data according to age groups whilst one study, (Bohannon, 2011) reported a range of the minimum age to the maximum age included in the systematic review. Reference values would become difficult to interpret and observe any patterns of inclining or declining muscle strength if not stratified according to age groups. Comparing the same age groups of different populations would not be possible. In addition, the two systematic reviews stratified data in age groups above 50 years of age. It possible that data reporting normative reference values in the elderly is less available and thus the two systematic reviews focused on the elderly population. The elderly is also susceptible to ill health and disability. Developing data stratified specifically according to age groups such as 50-59,60-69 and 70-79 will assist relevant stakeholders in providing detailed information to aid clinical decision making.

The type of manual muscle testing differed across studies. Manual muscle testing, although standardized regarding procedure, is still dependent on the assessor. Differences in execution can impact the values and possibly explain the variation in data. Whilst the positioning used across the systematic reviews was standardized, the two types of testing used were namely break tests and make tests. The make test involves the participant applying a maximal force against a fixed point, the assessor. The break test involves the participant applying a maximal force at the end range of motion and should not ‘break’ the resistance applied by the assessor. Bohannon,(2011) reported studies using make and break tests whilst (Benfica *et al.*, 2018) only reported having used make tests. It is possible that (Benfica *et al.*, 2018) considered using makes tests due to

various factors revolving around using ‘break tests. These factors include inadequate assessor strength and a low measurement ceiling of a dynamometer to overcome a force generated by a larger muscle group e.g.) Quadriceps. Performing ‘make tests’ has the potential to provide close to accurate normative reference values without considering the strength needed by the tester.

Due to the poor methodological quality of the identified reviews, confidence in the use of the synthesised reference values is questionable. The quality of the systematic reviews was collectively assessed as “critically low”. The main highlighted issues revolving around the quality of the studies included poor reporting of the studies excluded and the lack of assessment of risk of bias of included studies. Whilst the rationale for exclusion of studies had been provided across all three systematic reviews, the listed studies were not included. It would be necessary to include evidence of the excluded studies as it further validates the methodological rigor of which the systematic review perpetuates. A list of excluded studies further provides us with evidence regarding the populations developing normative reference data in different languages, different evaluation methods and varying study designs. This information can further inform the confidence we have in the conclusion of the systematic review. Benfica *et al*,(2018) was the single only study that reported using a tool to report risk of bias. However, all studies failed to report the influence of the risk of bias on included studies in the results of each systematic review. This is an issue as our trustworthiness in the results of the systematic reviews is affected. It may become difficult when interpreting the implications of the results, competing interests without considering the risk of bias of included studies. In addition, publication bias had not been assessed across all three studies.

The normative reference values for muscle strength were closely reviewed between gender groups. We argue thatmuscle strength in male groups should be greater than female groups as well as the dominant limb presenting as stronger than the non-dominant limb. It had been identified across all three systematic reviews that males were stronger than females across all age groups with a gradual decline as participants aged. However, it had been noticed specifically in males in age groups above 60 that the non-dominant upper limb was stronger than the dominant upper limb. This was observed for both the Deltoid and Quadricep muscle groups. The varying reasons for this observation can be speculated. It’s possible that with time, the dominant limb develops fatigue and poor endurance due to repetitive movements and overuse, specifically in these age groups. As a result, whenthe muscle undergoes manual muscle testing where a maximal force is needs to be applied, only a submaximal force is possible. Associated age-related health factors in these age groups would also need to be taken in to account.

2.10.2 Exercise capacity

The synthesised data for exercise capacity testing highlighted four issues. These issues included 1) studies reporting least developed economies; 2) variation in the stratification of age; 3) poor methodological quality andvarying methods of defining 'healthy' and 4) variation in pathway shape, distance; and the number of trials executed.

The geographical distribution of the populations performing the 6MWT were illustrated and analysed. It had been highlighted that not a single study had been carried out in a least developed economy in respect of the timeline of the latest literature search. We argue that the 6MWT is difficult to execute in an under resourced, overcrowded, and low economic setting. The 6MWT requires a 30m straight pathway that is clear, quiet and distraction free. It is also a possibility that the testing guidelines have not been made available in the respective country's language. The main mode of transport in least developed countries comprise of commuting on foot. We argue that the willingness of participants wouldbe less likely to walk without purpose or incentive. (Salbach *et al.*, 2015) included mostly populations from developed economies. The nine additional studies included further 6MWT data from developing economies.
Additional studies further broadened the geographical distribution of data in developing populations, specifically the North African populations. The studies published in the North African populations are the only studies illustrating the distance walked in six minutes on the African continent.

In addition to the large spread of the populations reported, a variety of age groups have been reported. Six studies reported stratifying data according to age groups as illustrated in (Table 2.6), whilst the latter reported age groups as a range with resultant totals. Of these six studies, most studies (n=5) have been carried out in developed populations. It is also important to note that the studies that have stratified 6MWT data according to age groups have included age groups above the age of 65. As an individual reaches the threshold of 50, we argue that the risk of non-communicable disease and comorbidities increase (Benedict and Jr, 2018). The stratification of age above 50 may have the potential to provide focused data for these age groups. This in turn would assist healthcare practitioners and clinicians in focused approach to diagnosis, treatment, and prevention. The lack of stratification of age groups hampers our interpretability of the data. This is due to fact that a total value for a range of ages is not a true reflection of the distance walked by either an adolescent or an elderly individual. Theability to observe potential patterns of the distance walked over a variety of age groups for a specific populationis not possible. This further affects our ability to arrive at conclusions as to why an elderly individual may walka shorter distance than a younger individual. Age specific data is necessary to make carefully tailored clinical decision making and refrain from generic approaches.

Apart from the variation in reported age groups and geographical distribution, issues regarding methodological quality were noted. Salbach *et al*,(2015) had assessed the methodological quality of their included studies and concluded that the failure to report the methods used to select participants and that most studies reported using convenience samples were key issues. These varying methodological issues affect our confidence in the interpretability of the results.

An important issue observed across all studies was defining eligibility criteria and a "healthy participant". Criteria differed between studies when defining a "healthy participant". Studies included participants that had a smoking history or were part of the overweight and obese categories when reporting Body Mass Index. Other studies excluded participants who had been placed into these categories and considered the included participants as "healthy". It can be considered that the criteria to justify a "healthy participant" is subjective and influenced by the demographical structure of the respective population. It would be important to further analyse the eligibility criteria followed when comparing normative reference values between populations to ensure consistency. In addition to this, poor reporting of the methods used to select participants further aggravates this issue.

All studies reported in (Table 2.3) were specifically time limited tests. The time limited was to six minutes. As ATS guidelines specify that the 6MWT should be walked comfortably over a 30m distance, not all studies had followed this course or distance. Studies included adapted distances of 13.3m, 15m ,18m,20m, 25m ,45.7m and 82.3m. In addition to the adapted distance walked, encouragement and environment was not standardised for adapted distances. A single study walking an adapted distance of 25m, instructed participants to walk at a fast pace initially and the repeat the test at a slow pace. Another study performed the 6MWT over 45.7m both indoors and outdoors. It is a possibility that poor standardisation of encouragement and environment in which the test is carried may affect the outcome of the test and thus validity. Comparing the outcomes of two or more populations with varying distances walked will not be possible. One study reported the lowest distances walked over an adapted distance. The study included in (Salbach *et al.*, 2015) reported a course of 20m rectangular course (6x4m) with the encouragement reported as 'walk as far as possible.' We argue that factors such as the amount of time taken for the participant to turn at each corner of the rectangle resulted in a significant decrease in the distance walked. Additional studies not included in the systematic review reported adapted distances of 13.3m, 15m and 18m. Turn-around time, adapted distances, encouragement and the use of standardized guidelines need to be further explored when interpreting data. The variation in the forementioned factors allows further understanding of the data at hand.

Lastly the number of trials, resting periods and scoring criteria differed between studies. Standardisation amongst studies were poor when reporting the number of trials and criteria to score tests carried over adapted distances. Studies that reported walking a 30m distance mostly followed ATS guidelines when scoring and executing trials. A single study included in (Salbach *et al.*, 2015) executed four trials and recorded the maximum distance of the four trials. Most studies included in the systematic review and additional studies performed more than one trial thus accounting for a possible learning effect. Four studies executing the 6MWT over an adapted distance reported performing only one trial. It remains a concern that the course, distance, lack of allowance for a learning effect may affect the confidence we have in the results of these studies. When observing studies that have performed the 6MWT over an adapted distance, it would be necessary to further consider the procedures, trials and scoring criteria used when analysing their results.

2.10.3 Maximal Inspiratory Pressure

Four issues have been highlighted after having synthesised the data retrieved for Maximal Inspiratory Pressure (MIP). The issues revolving around MIP reference values include poor methodological quality, poor standardization of procedures and positioning and lastly variation in the equipment used to produce a maximal inspiratory pressure.

The methodological quality of both studies was assessed according to their respective tools. The methodological quality of the systematic review after assessment resulted in a "critically low confidence" rating in the results of the review. The main methodological issues revolved around poor adherence to their protocol and poor reporting of the search strategies used. It was identified that (Mb *et al.*, 2014) did not report using a comprehensive search of literature and accessed less than two databases. The AMSTAR-2 tool identified that a list of excluded studies needs to be reported and is one of the critical domains of the tool. The systematic review showed no evidence of reporting studies that were excluded and reasons thereof. The poor methodological quality affects the credibility we have in the results. Since normative reference values potentially differ between populations, the lack of an extensive search, limits the potential studies including different populations that could have been retrieved from different databases. The lack of a comprehensive literature search also further limits retrieving more recent evidence reporting normative reference values.

A second methodological issue had been observed after assessing the additional study. Participants volunteered and were included in the study if they were considered "healthy". This brings about an aspect of "volunteer bias" when recruiting participants. To further unpack this, we speculate that volunteering participants may have different lifestyles, privileges, and characteristics. It possible that false results and generalizations will be made to a larger population based on this specific sample. There was also no evidence of the study reporting the number of participants that have dropped out of the study. This affects the confidence in the results that is being portrayed based on the number of participants recruited. It is possible that the study may have included the participants in their sample size and not reflected their data in the results due to discontinued testing. A great sense of uncertainty is created around the validity of the results and statistical power.

Both the systematic review and additional study did not report having adhered to a standardized guideline during their procedures and positioning. As a result, great variability was observed around the criteria that satisfiesthe assessor to stop assessing MIP. Criteria specifying the time taken to generate a MIP, the number of trials executed, and value chosen differed within (Mb *et al.*, 2014) and between the systematic review and additional study. Both studies commonly followed a time of 1.5 seconds to generate a MIP. Other time periods ranged from one second to a minimum of two seconds. The systematic review reported that some included studies did not have a time limited parameter and that the MIP was executed "without control". According to (ATS/ERS) (Gibson *et al.*, 2002), when assessing respiratory strength, a MIP should be maintained for 1.5 seconds.

This is to allow a maximum pressure to be sustained and recorded for one second at the least. The variation in the time interval used to sustain a MIP may affect the consistency of the results rendered and reproducibility. Comparison of MIPs between populations with differing time periods followed when generating MIPs may prove futile. This variation was also observed in the criteria used for stopping and number of trials executed through both studies.Poor standardisation affects our confidence in the quality of the results.

Lastly, ATS/ERS guidelines recommend that a rubber mouthpiece be used with a 2mm internal leak (Gibson *et al.*, 2002). Both studies reported using a 2mm leak whilst other studies included in the systematic review reporting using at minimum a 0.60 mm leak and maximum a 2 mm leak. Studies used a variety of mouthpieces including a “tube”, flanged, face mask and a diver type mouthpiece. Flanged mouth pieces have been said to result in lower MIP values when compared to rubber mouthpieces (Gibson *et al.*, 2002). It is noteworthy that the inconsistent use of standardised equipment when assessing MIP affects the comparability of reference values between studies and populations using varying equipment. It would be necessary to further consider the equipment used and procedures followed when analysing and comparing MIP normative reference values prior to clinical decision making.

2.10.4 Grip Strength

From the review of current data reporting on grip strength the following five observations are relevant: 1) there is no data from populations in developing economies; 2) the systematic review methodologies used to summarize data is of poor quality; 3) the role of hand dominance is unclear; 4) reporting of results vary and 5) the number of trials carried out vary when assessing grip strength. We will discuss the relevance of the forementioned observations.

Studies measuring grip strength have been carried out in different populations and age groups. It is evident from the review that the populations included in the systematic reviews measuring grip strength were from economic developed and developing economies (WESP 2019). Till July 2019, no studies have been published with data from theleast economic developing regions or countries with a greater challenged economic background. Two possible reasons could be that the least developed economies cannot afford the tools required to assess hand grip strength, or that the importance of hand grip strength has not been fully explored. Much progress has been madearound the development of reliable, cheap equipment which can be used to measure grip strength (Svens, 2005).This clinical field test provides reliable data on generalised weakness, lung function and mortality (Mgbemena,2019).

The second observation that we wish to highlight is the poor methodological quality of the systematic reviews included in the grip strength section. All included systematic reviews were rated as “critically low” according to AMSTAR-2 confidence rating tool. Poor consideration was given to the risk of bias of the individual studies included in each of the systematic reviews. In addition, the discussion of the effect of risk of bias in the results section in each of the systematic reviews were either minimal or absent. This consistent methodological issue affects our confidence in the results in the systematic reviews and the consistency of their study and conclusions reached. It would be necessary to consider this methodological issue when identifying and interpreting international normative reference values. Furthermore, not considering the differences in risk of bias between studieswill not assist in understanding the variation in the results in the studies. Understanding variation would aid us in interpreting international normative reference values.

The functionality of our hands is an important component of performing activities of daily living (ADLs) and thus the muscle strength required to perform these tasks. Hand grip strength differs between each respective hand according to dominance as well as gender. Handgrip strength is also a proxy for general weakness (Kamide *et al.*, 2015). In terms of primary based rehabilitation and disability, the dominant hand and resultant measure of strength is important when assessing hand function. Two of the five systematic reviews, namely Lifecourse, Unit and Medicine,(2014) and Kamide et al.,(2015), reported their normative reference values as pooled z-score and weighted mean respectively. The issue arises around understanding of these studies grip strength in terms of hand dominance as pooled scores and weighted means poorly represent which hand is stronger or patterns of dominancy.

Lifecourse, Unit and Medicine,(2014) reported normative reference values according to developed and developing economic regions thus making it difficult to compare the differences between genders within these regions.

Lastly, it was observed that the number of trials taken, and criteria used to stop the testing once satisfied with theresult was identified to be inconsistent amongst all five systematic reviews. The most chosen criteria for stopping were “maximum” or “best” measurement of the trials carried out. The number of trials varied between 1-3 and some studies included in the systematic reviews preferred using mean of the trials carried out. This inconsistency in trials results in poor reliability of the hand grip strength measure in association with inconsistencies of positioning.

2.10.5 Conclusion

International normative reference values have been developed and published across many populations and economic backgrounds for five clinical field tests used in primary based rehabilitation. There is widespread variation in normative reference values due to influencing factors that need to be taken into consideration. These factors include the geographical distribution according to the population’s economy, the procedures used to carry out the clinical field tests, the stratification of the identified normative reference values and methodological quality.

3 Chapter 3 – Primary Study

3.1 Background

South African health services, including primary based rehabilitation, are currently under strain due to the rising burden of non-communicable disease (NCD)(Mayosi *et al.*, 2009). Therapeutic exercise and lifestyle interventions are at the core in the management of non-communicable diseases (NCD's). Various field tests have been developed to assist therapists in prescribing exercise, but also to measure the effectiveness of intervention programs (Mckay *et al.*, 2012). Access to normative data for these field tests within the South African population is in its infancy (Ramlagan, Peltzer and Phaswana-mafuya, 2014). The lack of data poorly affects our understanding and interpretation of normal variation within the South African population.

Clinical field tests are measurement tools that are easily available, inexpensive and portable (Tveter, 2014). The measurement tools used in primary based rehabilitation also inform health related physical outcomes (Tveter, 2014). We have identified five clinical field tests used regularly in the management of non-communicable diseases (NCD's), namely the six-minute walk test (6MWT), assessment of a participants maximal inspiratory pressure (MIP), assessment of grip strength and assessment of Quadricep and Deltoid strength. After scoping the literature, we identified numerous reference values for the forementioned field tests. However, the majority of the data is representative of populations from the developing economies. Factors such as age, gender, BMI, socio-economic status has been identified as factors which affect the expected value for a specific test. It is not clear which of the populations or indeed if any of the populations which have reported reference values, can be used to compare the results of the field tests in a South African population.

The aim of this study is to describe age and gender specific values for five clinical field tests in a resource restrained metropolitan population sample in Cape Town, South Africa.

3.2 Research Methods and Design Research Methods and Design

A descriptive cross-sectional observational study design was utilized.

We used a **convenience sampling** method. The study population sample included "healthy" adult participants from resource restrained communities i.e. (Ravensmead, Uitsig and Parow). The setting used for data collection was Tygerberg Hospital as the hospital offers services to the forementioned communities. All apparently "healthy" adults accompanying an active out-patient or visiting hospitalised patients and found waiting in the general waiting areas of Tygerberg Hospital were eligible for inclusion. The principle investigator (PI) invited subjects to participate in the study. Participants were included if they were over the age of 18 years, provided written informed consent and reported no history of Tuberculosis (TB). Participants were excluded if they presented with signs and symptoms of undiagnosed Tuberculosis (TB), were pregnant, reported uncontrolled co-morbidities; were older than 65 years of age, presented with disabilities that restricted physical activity, or had undergone chest, eye, and abdominal surgery within the last three months. Uncontrolled co-morbidities were identified if the participant reported any co-morbidities for which they are not currently receiving treatment, exhibiting any symptoms on the day of screening, or and when partaking in the testing which may, in the opinion of the qualified therapist (PI), have a negative impact on the participant. Once the subjects were screened and provided written informed consent, an assessment appointment (60 minutes in duration) was scheduled at a date and time convenient for the subject.

Sample size calculation: As this is a descriptive study and no hypothesis was tested, we based the size of the sample on a recommendation by (Friedrichs *et al.*, 2009), to recruit a sample stratified according to six age groups to ensure a normal distribution of 20 participants per strata with 10 participants in each gender . However, after two months of data collection the country went into level 5 lockdown in an attempt to flatten thecurve of hospitalisations due to the COVID-19 pandemic. At the time of lockdown 35 participants were recruited which included participants in each of the six age groups. Gender distributions in each of the six age groups were equal. We decided to terminate participant recruitment, as it was not clear when we would be able to continue with participant recruitment.

Procedure: Assessments were performed in the Tygerberg Hospital Physiotherapy Department gym, on specific data collection days. Bookings were made in consultation with the department to ensure no disruption of the existing service. Subjects were instructed telephonically and via text message one day before their appointment, to abstain from smoking within one hour from testing; not eat or drink within two hours from testing and not consume alcohol within four hours from testing.

Data was collected using REDCap software (Research Electronic Data Capture). The assessment was carried out at five separate stations. The sequence of testing was randomized for each participant. The Primary investigator (PI) completed all assessments. A pilot test was performed before testing commenced. The aim was to determine the intra-rater reliability of the testing procedure used to test muscle strength, grip strength and maximal inspiratory pressure. Five random participants were recruited and then a re-assessed using the same tool by the same assessor one week later to determine intra-rater reliability. Inter-class correlation co-efficients (ICC) were calculated according to a two-way mixed model and absolute agreement. The POWERbreathe tool presented an (ICC:0.973), the JAMAR dynamometer for the left hand (ICC:0.966) and right hand (ICC:0.997) and the MICROFET-2 dynamometer for the left Deltoid (ICC:0.974), Right Deltoid(ICC:0.992) whilst the left Quadricep presented an (ICC:0.999) and right Quadricep (ICC:0.997) .This retrieved data suggests excellent intra-rater reliability of the testing procedure for all tests.

Station 1: EuroQol- 5 Dimension-5 Level (EQ-5D-5L) reporting health related quality of life outcomes and participant baseline demographics. The EQ-5D-5L is a tool requiring the participant to select the most relatable statement that is descriptive of their health on that specific day under each of the following five dimensions: mobility; self-care; usual activities; pain/discomfort; and anxiety or depression. A visual analogue scale (VAS) is included to determine the participants perceived state of health ranging between their worst health (0) and best health (100). The scale was used to further advocate for what a 'healthy' perceived state of health presented as in a sample of a 'healthy' South African population. This station was also used to weigh the patient and measure their height to calculate their body mass index.

Station 2: Exercise Capacity was tested using the six-minute walk test (6MWT) according to ATS/ERS guidelines ('ATS statement: guidelines for the six-minute walk test.', 2002). The 6MWT involves an individual walking a straight 30m pathway for six minutes at a comfortable pace. The total distance covered in six minutes is recorded. Two six-minute walk testswith 30 minutes in between were performed by the participants to account for a possible learning effect. The values tabulated represent the best achieved distance of the two tests .80 % of participants achieved a greater 6MWD on the second 6MWT. ATS guidelines were followed when executing the six-minute walk test which involves noting the reasons for stopping and recording the participants heart rate and oxygen saturation prior tothe test (baseline), after the test and one minute post testing. No participants stopped during either of the two 6MWT's, and could complete both tests without incident

Station 3: Grip strength was tested using a JAMAR dynamometer with the participant in a seated position with their elbow flexed at 90 degrees. The participant was instructed to hold a Maximal Voluntary Isometric Contraction (MVIC) for 3 seconds before releasing.

Station 4: The Quadricep muscle strength was measured with a MICROFET-2 Hand-Held dynamometer. The Quadricep muscle was tested in a sitting position using a make test, involving the participant generating a Maximal Voluntary Isometric Contraction (MVIC) during knee extension against the Primary Investigator (PI).

Station 5: The Maximal Inspiratory Pressure was measured with an electronic hand-held loading device (POWERbreathe® KH1, HaB International Ltd., Southam, UK) according to the American Thoracic Society and European Respiratory Society standards (ATS/ERS) standards. (Issues *et al.*, 2002).

Station 6: The Deltoid muscle strength was measured with a MICROFET-2 Hand-Held dynamometer. The Deltoid muscle was tested in supine using a make test, involving the participant generating a Maximal Voluntary Isometric Contraction (MVIC) during shoulder abduction against the Primary Investigator (PI).

*Data Analysis***:** Data was imported from Redcap software and analysed using IBM SPSS version 20. Descriptive statistics were used for analysis and data is presented as mean and standard deviation (mean ±SD) when normally distribution, and median inter-quartile range (IQR) when not. We also included a measure to describe the variability of the data between our primary data and international data. To compare the South African cohort to reported reference values for the different field tests, a meta-analysis of data was done and presented as a scatter plot, when data was comparable. Muscle strength and Grip strength were not plotted for comparison due to the heterogeneity in the manner the data was presented in the included studies. We plotted our primary data to select additional studies identified from our scoping review to compare exercise capacity and maximal inspiratory pressure between studies for both genders due to their homogenous nature. Muscle strength and Grip strength normative reference values was tabulated and described narratively whilst Exercise Capacity and MIP were described by means of scatter plots and described narratively.

Study approval was obtained from the committee for human research of Stellenbosch University (SU) (S19/10/219). The study was conducted according to South African guidelines for good clinical practice and the Medical Research Council (MRC) Ethical Guidelines for Research. All participants provided informed written consent. Permission was obtained from the Department of Health to recruit healthy participants visiting the hospital complex.

3.3 Results

3.3.1 Demographics

Thirty-five participants agreed to participate in the study. The average age of participants was (39.5±14), with a range between 18-62 years of age (Table 3.1). The participants were stratified according to six age groups (18-25,26-35,36-45,46-55 and 56-65) and gender. The total average Body Mass Index was (27.5±7.3). An estimated thirty one percent of the sample fell into the overweight categories and 31.43% of the sample fell into the obese category. It was observed that 22.86% of females fell into the obese category compared to the minimal 8.57% of males that fellinto the obese category. A percentage of the total sample is presented according the category of the respective BMI category of the participants. Nineteen or 54.29% of participants reported being employed whilst (n=16), 45.71% reported unemployment. Most participants reported not having any co-morbidities to their knowledge (n=27) 77.14%, whilst (n=8) 22.86% of participants reported having co-morbidities. Of the eight participants with co-morbidities (n=5) 62.5% reported having Hypertension, (n=4) 50% reported having increased cholesterol levels and one participant reported having diabetes.

Table 3.1 Anthropometric characteristics of the study population

Characteristic	**Unit**	**All participants (n=35) Mean ±SD**	**Male (n=16) Mean ±SD**	**Female (n=19) Mean ±SD**
Age	(Years)	39.46 ± 13.81	39.88 ± 12.43	39.11 ± 14.85
Height	(cm)	166.4 ± 9.46	172.13± 7.92	161.58 ± 7.82
Weight	(kg)	75.81 ± 19.58	74.06 ± 16.14	77.29 ± 21.95
Body Mass Index	(Kg/m^2)	27.47 ±7.24	24.97 ±5.13	29.58 ±8.05
	Underweight < 18.50	17.14%	11.43%	5.71%
	Healthy Weight Range 18.50 - 24.99	20%	5.71%	14.29%
	Overweight 25.00 - 29.99	31.43%	20%	11.43%
	Obese 30 or more	31.43%	8.57%	22.86%

3.3.2 Health Related Quality of Life Measure (EQ-5D-5L)

Participants reported a perceived health status of (83.21±14.13). 100% of participants reported having no problems with washing or dressing themselves. An estimated six percent, (n=2) of the participants had slight problems walking about under the "mobility" dimension and (n=2) 5.71% of the participants slight problems performing their usual activities under the "usual activities" dimension. It was reported that (n=4)11.43% of the sample population reported having slight pain and discomfort and (n=3) 8.57% of the population reported being slightlyanxious or depressed.

3.3.3 Descriptive results

Although only data was collected from 35 participants, a fairly even distribution of the number of participants in each age group was maintained between five to eight participants. The "36-45" age group presented data for the least number of participants. Due to a lack of participants, only a single female individual recruited represented the "36-45" age group. Data was otherwise presented as (mean ± standard deviation) due to a normal distribution.

3.3.3.1 Peripheral Muscle strength

Normative reference value data for Quadriceps and Deltoid muscle strength stratified into six age groups for both genders is illustrated (Table 3.2). We also reported on right and left limb strength separately. In an estimated ninety one percent, (n=32) of participants, dominance was reported in the right upper limb whilst (n=3) 8.57% of the total sample reported dominance in the left upper limb. In the male group (n=16), (n=14) 87.5% reported dominance in theright upper limb whilst (n=2) 12.5% of males reported dominance in the left upper limb. In the female group (n=19), (n=18) 94.7% reported dominance in the right upper limb whilst (n=1) 12.5% of females reported dominance in the left upper limb.

In (n=34) 97.14% participants, dominance was reported in the right lower limb whilst (n=1) 2.86 % of the total sample reported dominance in the left lower limb. In the male group (n=16), (n=15) 93.75% reported dominance in the right lower limb whilst (n=1) 6.25% of males reported dominance in the left lower limb. In the female group (n=19), (n=19) 54.29% reported dominance in the right lower limb whilst no females reported dominance in the left lower limb. The difference in upper limb and lower limb dominance can be speculated. We argue this discrepancy be attributed to 1) participants having poor awareness of which limb is more dominant 2) different 'normal' gait patterns used by participants or 3) some participants are ambidextrous and have not reported it.

3.3.3.2 Grip Strength

Normative reference value data for grip strength six age groups for both genders is illustrated (Table 3.2). Right and left hand values are reported separately. Dominance reported for grip strength is the same as the reported for upper limb dominance for peripheral muscle strength.

Table 3.2 Reference Values for muscle strength for males and females.

Deltoid Muscle strength (Newtons)							
Age group	**N=**	Total (n=35) Mean ±SD		Male (n=16) Mean ±SD		Female (n=19) Mean ±SD	
		Right	Left	Right	Left	Right	Left
18-25	**7**	152.6±43.97	135.73±35.20	201.6±0.3	179.25±9.75	133±36.91	118.32±25.22
26-35	**8**	158.61±52.63	162.9±64.89	186.5±60.66	207.93±58.62	130.75±17.55	117.88±30.53
36-45	**5**	179.78±58.69	188.88±61.94	190.38±61.17	206.3±57.25	137.4	119.2
46-55	**7**	160.93±32.58	144.56±31.65	197.7±5.1	174.35±15.15	146.22±26.8	132.64±28.52
56-65	**8**	152.74±41.55	159.69±46.02	176.48±34.5	186.58±43.74	129±33.73	132.8±29.62
Total		159.55±46.88	156.77±52.14	165.02±46.23	161.88±53	159.55±46.88	156.77±52.14
	Quadricep Muscle strength (Newtons)						
Age group	**N=**	Total (n=35) Mean ±SD		Male (n=16) Mean ±SD		Female (n=19) Mean ±SD	
		Right	Left	Right	Left	Right	Left
18-25	**7**	242.8±69.04	225.93±61.29	232±6	225.4±3.7	247.12±81.2	226.14±72.48
26-35	**8**	216.01±64.95	208.35±49.59	263.8±43.38	246.68±18.16	168.23±44.57	170.03±40.63
36-45	**5**	305.7±90.31	316.64±122.92	318.4±96.9	335.43±130.85	254.9	241.5
46-55	**7**	250.27±55.86	251.06±70.13	290.7±43.8	287.8±58.7	234.1±51.82	236.36±68.93
56-65	**8**	249.2±67.6	219.3±66.4	295.83±50.53	276.68±29.08	202.58±47.31	161.93±37.26
Total		248.62±73.94	238.88±81.8	252.13±75	246.28±81.12	248.62±73.94	238.38±81.8
Grip strength (Kg)							
Age group	**N=**	All subjects (n=35) Mean ±SD		Male (n=16) Mean ±SD		Female (n=19) Mean ±SD	
		Right	Left	Right	Left	Right	Left
18-25	**7**	35±5.98	33.43±6	41±0	39±1	32.6±5.46	31.2±5.71
26-35	**8**	41±11.10	39.63±12.13	48.75±10.87	50.5±6.87	33.25±2.86	28.75±3.27
36-45	**5**	48.8±9.35	50.2±9.81	52±7.62	53.25±8.58	36	38
46-55	**7**	36.71±7.09	33.43±6.41	47±5	39.5±3.5	32.6±1.02	31±5.66
56-65	**8**	37.38±7.89	34.38±6.26	44.25±4.60	38.75±3.96	30.5±2.96	30±4.95
Total		39.23±9.57	37.46±10.23	40.32±9.58	38.61±10.17	39.23±9.57	37.46±10.23

3.3.3.3 Maximal inspiratory muscle strength

Normative reference values for maximal inspiratory pressure (MIP) stratified over six age groups for both genders is illustrated (Table 3.5). The MIP reference value was recorded after three attempts and the best of the three attempts was recorded.

3.3.3.4 Exercise Capacity

Exercise capacity reference values is illustrated as six-minute walk test distance in meters(6MWD). Normative reference values for 6MWD stratified over six age groups for both genders is illustrated (Table 3.5). Physiological variables including heart rate and oxygen saturation was recorded before and after the six-minute walk test is illustrated in (Table 3.3). According to ATS guidelines, data regarding the rate of dyspnoea needs to be recorded at baseline, after the test and then one minute later. The Borg scale uses a numerical scale from 0-10 assessing the rate of dyspnoea according to the participants subjective judgement. (Table 3.4) illustrated the number and percentage of participants experiencing a specific level of dyspnoea according to the Borg scale at three measurements before and after both 6MWTs. No dyspnoea score was rated more than 3 (moderate dyspnoea) in both tests.

Table 3.3 Physiological Variables during the six minute walk test (mean ± SD)

Physiological variables recorded during the 6MWT	**Heart rate (Baseline)**	**Heart rate immediately after test**	**Heart rate 1 minute after the test**	**Saturation (Baseline)**	**Saturation Immediately after test**	**Saturation 1 minute after the test**
6MWT 1	72.17±10.15	89.86±18.03	76.57±13.13	98.11±1.05	98.37±0.84	98.8±0.96
6MWT 2	72.37±10.97	94.66±17.19	77.17±12.12	97.86±1.14	98.11±1.08	98.06±0.97

Table 3.4 Borg Scale data recorded during 6MWT 1 and 2 (n, %)

Rate of Dyspnoea according to the Borg scale	**At Baseline**	**Post 6MWT**	**One minute post 6MWT**
6MWT 1 (n= 35 participants)			
0 Nothing at all	(n=39) 68.6%	(n=14) 40%	(n=28) 80%
0.5 Very, very slight	(n=4) 11.4%	(n=12) 34.3%	(n=5) 14.3%
1 Very Slight	(n=1) 2.9%	(n=7) 20%	(n=2) 5.7%
2 Slight (light)	(n=1) 2.9%	(n=1) 2.9%	(n=0)
3 Moderate	(n=0)	(n=1) 2.9%	(n=0)
6MWT 2 (n= 35 participants)			
0 Nothing at all	(n=26) 74.3%	(n=1) 2.9%	(n=28) 80%
0.5 Very, very slight	(n=8) 22.3%	(n=14) 40%	(n=5) 14.3%
1 Very Slight	(n=1) 2.9%	(n=8) 22.9%	(n=2) 5.7%
2 Slight (light)	(n=0)	(n=2) 5.7%	(n=0)
3 Moderate	(n=0)	(n=0)	(n=0)

Table 3.5 Normative reference values of MIP and 6MWD for Males and Females (mean ± SD).

Maximal Inspiratory Pressure (MIP)(cmH_20)				
Age group	**N=**	All subjects (n=35) Mean ±SD	Male (n=16) Mean ±SD	Female (n=19) Mean ±SD
18-25	**7**	87.43±23.9	99±28	82.8±20.27
26-35	**8**	97.25±25.05	113.75±20.52	80.75±17.02
36-45	**5**	111.2±30.05	119±28.71	80
46-55	**7**	89.71±32.77	130.5±5.5	73.4±23.65
56-65	**8**	92.25±17.92	102.75±16.33	81.75±12.45
Total		94.63 ±27.06	96.29±27.95	94.63±27.06
6MWD Six-minute walk test distance(m)				
Age group	**N=**	All subjects (n=35) Mean ±SD	Male (n=16) Mean ±SD	Female (n=19) Mean ±SD
18-25	**7**	458.3±59.23	436.25±40.75	467.12±63.05
26-35	**8**	484.31±81.41	549.75±45.35	418.88±51.33
36-45	**5**	501.2±42.96	494.75±45.82	527
46-55	**7**	448.66±42.47	501±14	427.72±30.21
56-65	**8**	476.96±74.08	513.38±64.42	440.55±64.61
Total		472.71±66.36	470.98±65.86	472.71±66.36

3.3.3.5 Comparison to International Data

Scatter plots was used as a visual comparison of a healthy South African cohort of data to international data for males (Figures 3.1, 3.2) and females (Figure 3.3, 3.4). Population mean and 95% Confidence Intervals) for exercise capacity and maximal inspiratory pressure was calculated.

The maximal inspiratory pressure scatter plot, plotted reference values from our primary data (South Africa – developing economy) and Brazilian reference values (developing economy) (Pessoa, Neto and Montemezzo, 2014a) for both males (Figure 3.1) and females (Figure 3.2). There was no overlap in the 95% Confidence Intervals of the males indicating that the samples were taken from different populations. It is interesting to note that the 95% Confidence Intervals for the two samples of women did overlap possibly indicating a more homogenous population.

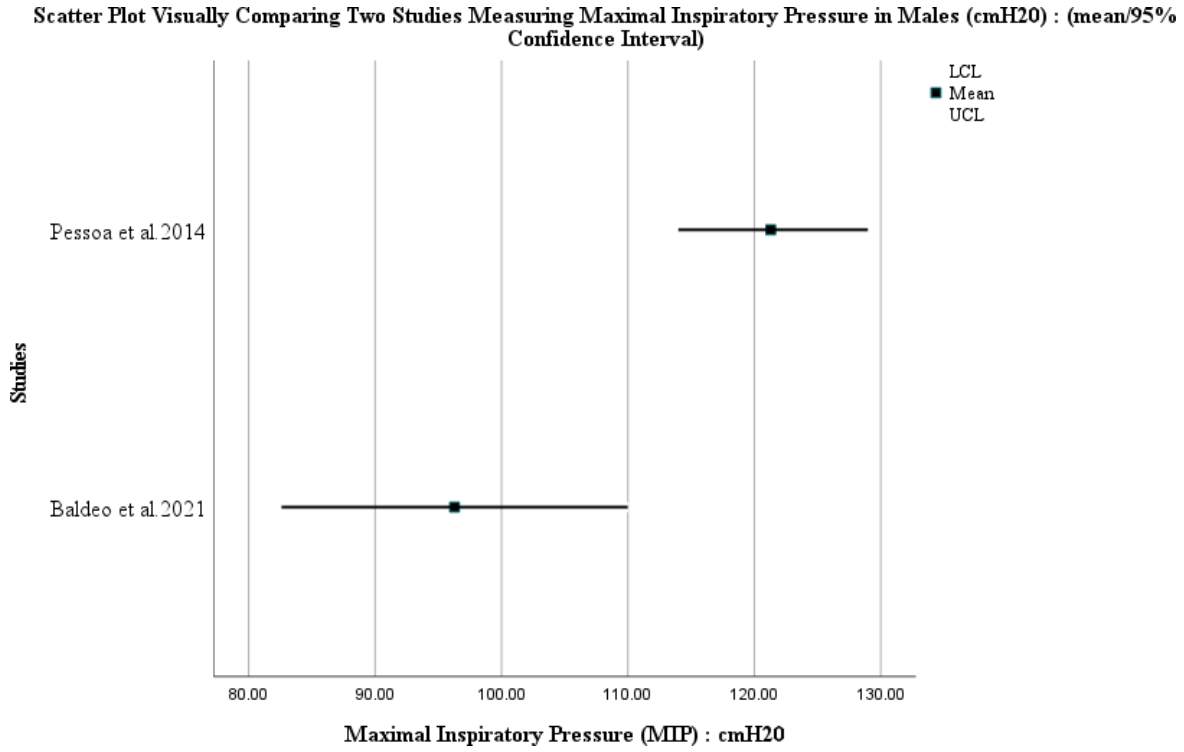

Figure 3.1 Scatter plots visually comparing studies measuring Maximal Inspiratory Pressure (MIP) in males.

LCL = Lower Confidence Level/Interval

UCL = Upper Confidence Level/Interval

Baldeo et al.2021 – South Africa (n=16)

Pessoa et al.2014 – Brazil (n=60)

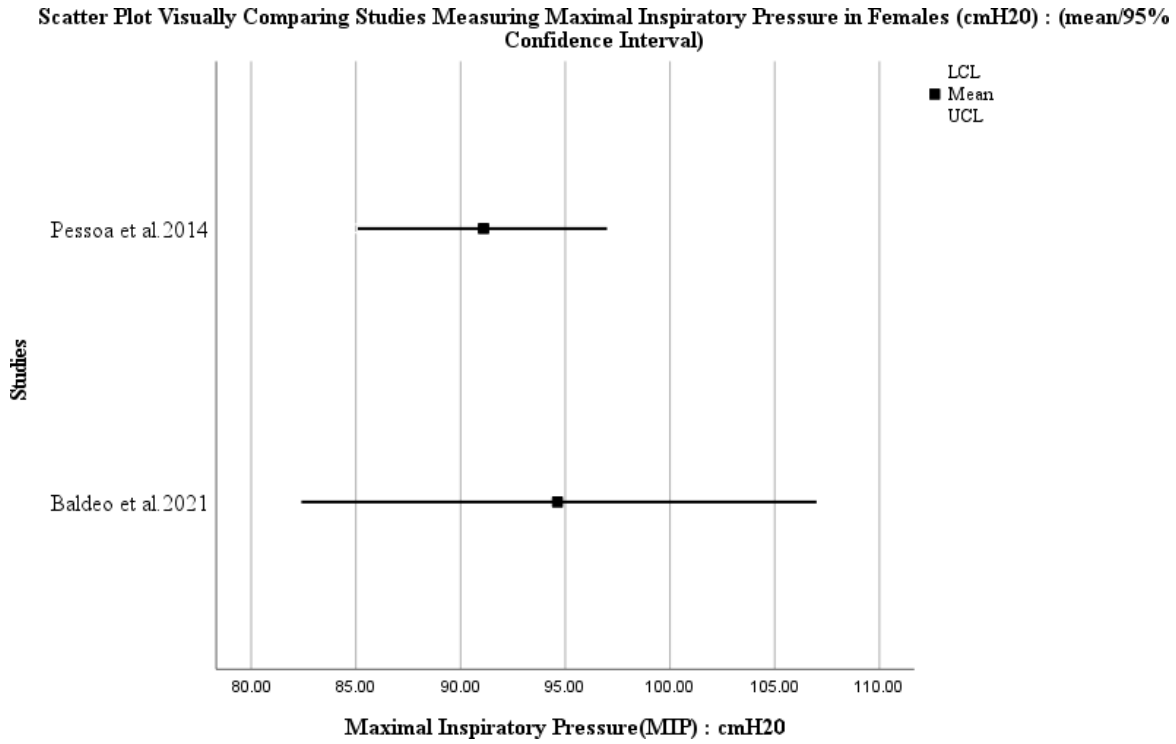

Figure 3.2: Scatter plots visually comparing studies measuring Maximal Inspiratory Pressure (MIP) in females.

LCL = Lower Confidence Level/Interval

UCL = Upper Confidence Level/Interval

Baldeo et al.2021 – South Africa (n=19)

Pessoa et al.2014 – Brazil (n=74)

The scatter plots compared exercise capacity plotted reference values from our primary data to North African and Mediterranean populations (Developing economies) (Bourahli, Bougrida and Martani, 2016); India (Developing economy) (Vaish *et al*.,2013), China (Developed economy) (Zou, Zhang, *et al.*, 2017) and (Zou, Zhu, *et al.*, 2017) (update). The economic background of populations was classified according to the (WESP) World Economic and Situation Prospect guideline (Situation, 2015). The study carried out in India, only reportednormative reference values for exercise capacity in Males. None of the studies 95% CI overlapped indicating heterogenous populations.

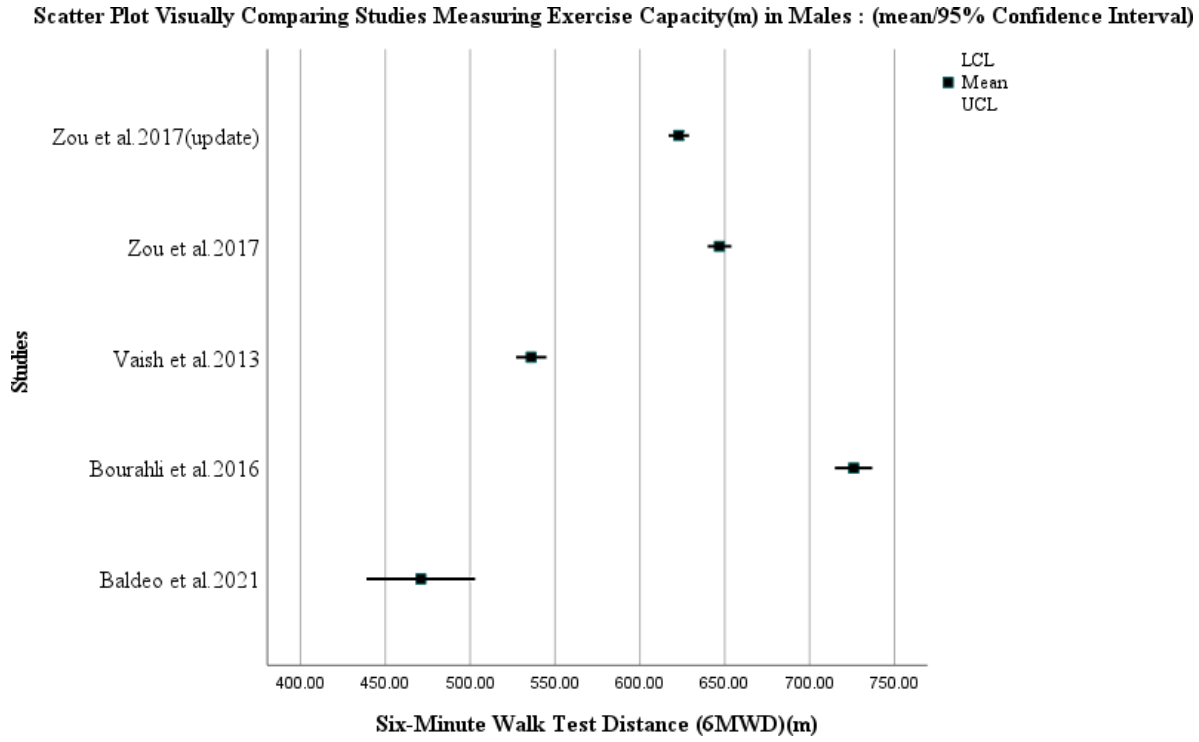

Figure 3.3 Scatter plots visually comparing studies measuring Six minute Walk Test Distance (6MWD) in males.

LCL = Lower Confidence Level/Interval

UCL = Upper Confidence Level/Interval

Baldeo et al.2021 – South Africa (n=16)

Bourahli et al. 2016 – North African and Mediterranean countries (n=100)

Vaish et al.2013 – India (n=101)

Zou et al.2017 – China (n=179)

Zou et al.2017 (update) – China (n=324)

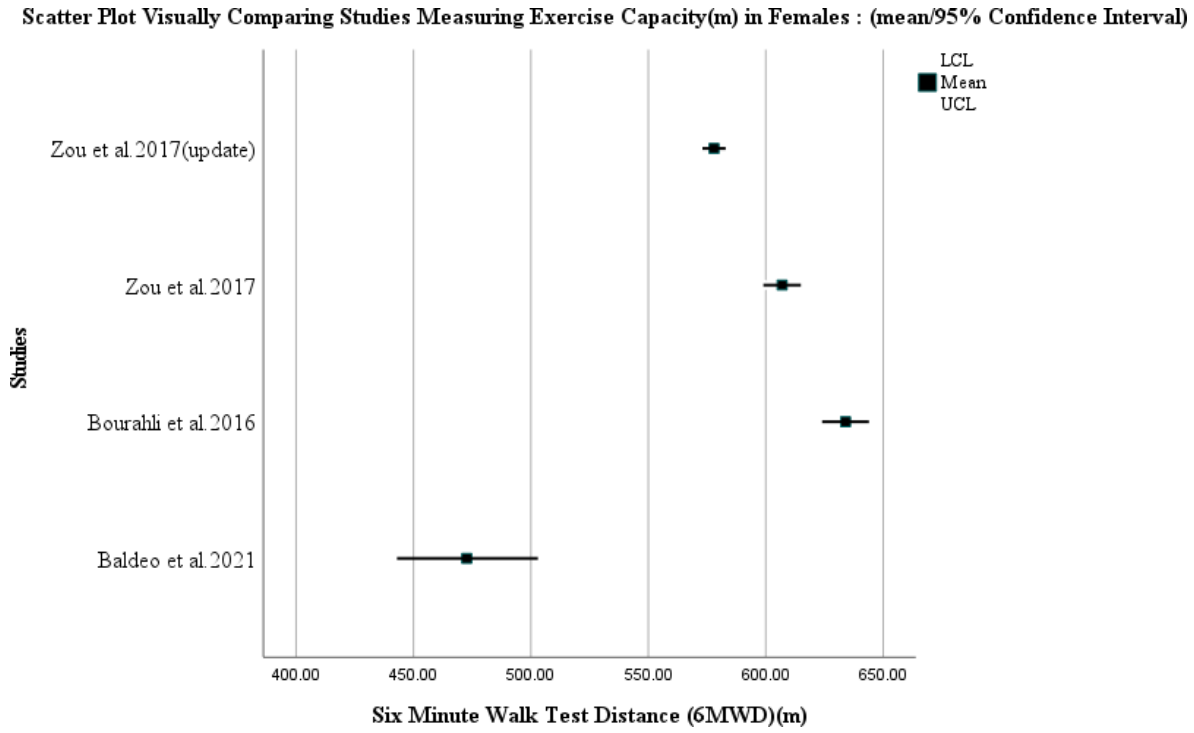

Figure 3.4: Scatter plots visually comparing studies measuring Six minute Walk Test Distance (6MWD) in females.

LCL = Lower Confidence Level/Interval

UCL = Upper Confidence Level/Interval

Baldeo et al.2021 – South Africa (n=19)

Bourahli et al. 2016 – North African and Mediterranean countries (n=100)

Zou et al.2017 – China (n=176)

Zou et al.2017 (update) – China (n=319)

3.4 Discussion

Age and gender stratified values have been summarized for the five clinical field tests in an apparently "healthy" adult population sample from a resource restrained metropolitan community in South Africa. Interesting findings related to understanding a 'healthy" population within a South African context were made. More than 31.43%, (n=11) of this sample can be classified as overweight. This finding can just be by chance, but it could also be indicative of a widespread looming health concern. Obesity has been linked to the development of various NCD's. Hypertension, increased cholesterol and diabetesform part of the cardiovascular diseases that form 12% of South Africa's burden of NCD (Mayosi *et al.*, 2009). Factors such as decreased physical activity and poor diet has been said to contribute NCDs in South Africa (Mayosi *et al.*, 2009). It is also notable that obesity is more prevalent in the female participants. Changing lifestyle and individual choices with greater access to fast foods in a metropolitanarea plays a role in the potential impact of obesity on outcomes of field tests exploring muscle strength, six- minute walk distance, grip strength, HRQoL and maximal inspiratory pressure.

The second finding that "challenges" the criteria used for inclusion into the study and thus identifying "healthy" participants, are the reported health related quality of life measure outcomes. The potential effect of pain and mental health needs to be considered when including participants. We argue that the level of pain being experienced is subjective and that state of mental health can affect test outcomes. This further questions if an individual can be regarded as 'healthy' if they report problems under the different domains included in the tool. The findings highlight the difficulty in defining a "healthy" population. These potential "unhealthy" variables could just be part of the normal distribution within a population, however if the variables have a significant effect on the outcome of the field tests we then need to question if it can still be used as a reference value?

A widespread variation was observed when visually comparing our results (mean and Confidence Intervals) to international studies reporting reference values for the 6MWT. The imprecision of our data set is understandable due to the small sample size. While recruiting a larger sample will improve the precision of our data set, the data is suggesting that the populations used to generate reference values for the 6MWT is very different from the South African population. Comparing the 6MWT results of a diseased patient in South Africa to existing reference values could lead to incorrect clinical decisions. Work is needed to develop reference 6MWD equations for South Africa.

The comparison of our MIP data to the Brazilian cohort raises interesting questions regarding comparisons of the different sexes. While the male populations seemed heterogenous, the female population used for MIP was homogenous. It is possible that the male groups presented heterogeneously due to the age groups for males presenting data similarly. Secondly, that obesity could have affected the performance of the MIP in the female group due to an abdominal mass placing a force on the diaphragm and thus a mechanical disadvantage. Data is often used categorically with specific cut offs points that are used to describe weak muscles (Rodrigues *et al.*, 2017). Defining South African specific MIP cut off points could be valuable as we move forward in understanding the range of diaphragm strength in our South African population.

We used a 'make' test to document Quadricep and Deltoid muscle strength. Whilst we were unable to compare our results to international published studies, it does seem as if the type of manual muscle testing, we used could differentiate different strengths in the different age categories – as one would expect. This can highlight a possibility of issues with technique when performing the 'make' test. These issues include inadequate tester strength, poor standardisation in technique used and ceiling measurement limits of the instrument used. All international studies presented greater means and narrow confidence intervals. Our study visually presented wide confidence intervals further informing poor precision and generalisability. Our field test outcome did not fit into the means and confidence intervals of international studies indicating heterogenous populations.

3.5 Limitations

This study has several limitations. Firstly, due to the COVID-19 pandemic, reference values were based on a small sample size as the recruitment and testing of participants had halted. The 35 participants may not present a true reflection of a South African population. Secondly, due to the small sample size, normal distribution was not achieved as a single participant had been recruited to represent an entire age group and gender thus omitting the generalisability of the normative data. Thirdly, more females than males were recruited. Lastly, criteria defining 'healthy' in a South African context needs to further be established moving forward.

3.6 Conclusion

The reference values we have reported, provide insight into the distribution of values in an age and gender stratified sample of healthy adults in South Africa. The results caution the use of published reference values to make clinical decisions for management of a South African diseased population. Work is needed to develop South African specific reference equations and cut off points for the five clinical field tests investigated in this study. A larger sample size is required ensuring a normal distribution to further establish trustworthy South African reference values.

4 Chapter 4 – Discussion

4.1 Overall Discussion

Normative reference values have been widely available at an international level, however the availability of normative reference values at a national level is questionable. Reference values are used in primary based rehabilitation and inform clinical decision making, treatment and prognosis.

The scoping review identified systematic reviews that have summarised data including population demographics, variation in procedures and methodological rigor or lack thereof. Where systematic reviews failed to include studies published more recently, additional studies were yielded according to a secondary search thus providing an update in the evidence for the specific clinical field test. The data synthesised in chapter two highlighted the reference values used in primary based rehabilitation,are most commonly available in populations that are classified as developed and developing economies, according to the WESP guideline (Situation, 2015). Poor standardisation and methodological quality across the systematic reviews emphasized the need to further explore the methodology followed and procedures carried out before interpretingreference values. The results of the scoping review suggest a widespread variation of reference values in developed and developing economies. A consistent lack of reference values exists in least developed populations.

The spread and mean described in the additional studies included in the clinical field tests, MIP and 6MWT, were further used as a visual comparator to our primary study to possibly identify similarities in population samples. Due to the variation in our primary study data and discrepancies in distribution of the reference values when visually compared to international comparators, we argue that reference values for a South African population need to be further explored and established. To our knowledge, Ramlagan, Peltzer and Phaswana-mafuya,(2014) has produced reference values for hand grip strength specific to participants over the age of fifty in South Africa. The data provided by this author is limited to one clinical field test and focuses on a specific age group. References values have otherwise been highlighted in the African continent for hand grip strength Lifecourse, Unit and Medicine,(2014). According to Lifecourse, Unit and Medicine,(2014), African studies reported pooled z-scores of (-1.34) compared to European studies that reported pooled z-scores of (0.13) for hand grip strength. A Z-score measures the standard deviations a data point is from the mean where ‘0’ would indicate that the data point falls on the mean. Positive values would indicate the data point falls above the mean whilst negative values will indicate that the data point is below the mean. These Z-scores illustrate a significant difference between developing and developed economies. The results of the scoping review further support our argument that our primary data is different from that of the identified international normative reference values.

Our scoping review suggested numerous issues regarding the standardisation of procedures and positioning for each clinical field test. These issues were highlighted with the further purpose of assisting clinicians with clinical decision making. When further investigating exercise capacity, the issues explored also informed our approach to our primary study. The issues highlighted focused on the varying distances walked, the shape of the pathway, inconsistent number of trials and poor stratification of 6MWT data according to age groups. When visually comparing our 6MWT data on a scatter plot to the additional studies reporting distances walked in our literature review, South African data for both Males and Females was significantly less than India (developing economy), North African and Mediterranean countries (developing economies) and China (developing economy)(Figure 3.3 and 3.4).

It can be suggested that when establishing normative reference values for a 'healthy' cohort, healthy needs to be explicitly defined. Authors summarized varying criteria in our literature review when defining 'healthy'. Common criteria described the exclusion of participants in the overweight and obese Body Mass Index (BMI) categories, smokers and participants with neuromuscular disease, heart disease or respiratory disease. The EQ-5D-5L tool measured the perceived health status of participants in the primary study as an average of 83.21% (83.21±14.13). However, the relationship between physical health status and perceived health status need to be further investigated. Factors such as Body Mass Index (BMI) play a role in a population's definition of 'healthy'. Majority of our sampled participants fell into the overweight category (31.43%) and obese category (31.43%).

Our primary study intended to highlight descriptive reference values for clinical field tests used in primary based rehabilitation. The value of the references values provides insight into 'normative' variation in a South African context. The references values produced were stratified according to age and gender groups with the purpose on providing information that will aid clinical decision making and tailor diagnosis and prognosis accordingly. Although a limited sample size was used, affecting the precision and generalisability of our results, these reference values form the foundation to further establish South African reference values.

It is possible that a great difference exists between the reference values produced by developed economies and references values produced by developing economies. Although a substantial number of normative reference values have been produced in developing economies, a lack of standardization and poor methodological quality greatly affect the interpretability of these normative reference values. Our findings provide a first look into normal variation for muscle strength, grip strength, exercise capacity, respiratory strength, and perceived health status in a South African context. Hand grip strength also varies according to different population groups within South Africa (Ramlagan, Peltzer and Phaswana-mafuya, 2014). We argue thatfurther research would be required to establish precise and generalizable South African normative reference values.

4.2 Recommendations

A larger sample size would be recommended in future studies to increase the precision and generalizability of the results.

Implementation of a recruitment method to ensure equal recruitment of male and female participants. This would be to ensure a normal distribution of which the interpretability of the results improve.

Further research is necessary to define 'healthy' in a South African context. Current literature has presented varying definitions of 'healthy'. We need to consider that South Africa is a developing economy, with a rising burden of non-communicable disease (NCD) (Mayosi *et al.*, 2009).

Further research regarding the use of the EQ-5D-5L tool needs to be explored. It is important to further investigate the relationship between perceived health status and physical outcome in a South African context.

4.3 Limitations

4.3.1 Scoping Review

The following limitations were identified in the scoping review:

- The primary and secondary search had initially been conducted at the end of 2019. No follow up search for new additional articles have been performed. A possibility exists that newly published studies describing reference values for different populations have been produced. This is seen as a limitation as these results are not included in our literature review. We aim to publish the scoping review and the search will thus be updated before submission.
- Five studies were excluded due to being written in a language other than English. Further on, studies were excluded due to the language filter function available in some of the databases. This can be considered a limitation as many studies could have been excluded that may have contributed to the results of our literature review.
- Chosen databases such as Pubmed, Science Direct, CINAHL, MEDLINE, Web of Science and Scopus were used. The studies retrieved focused on populations from developing and developed economies. Alternative databases that were not accessed and not available in English may have provided valuable information on populations from developing and least developed economies.

4.3.2 Primary Study

The following limitations were identified in the Primary Study:

- A small sample size was used due to the start of the COVID-19 pandemic during data collection. This limitation reduces the precision and interpretability of our results. However, the sample selected was stratified and included all ages and a good distribution of gender. Larger samples would improve the precision (95% Confidence Intervals).
- The criteria used for inclusion of 'healthy' participants required an individual to be over the age of 18, to provide written informed consent and have no history of Tuberculosis (TB). We argue that our sample was not considered 'healthy' based on the health-related quality of life (HRQoL) outcomes along with the inconsistent definition of 'health' by the World Health Organisation. A more defined criteria for inclusion of 'healthy' South Africans would have yielded a more trustworthy sample of 'healthy' participants.

4.4 Strengths

4.4.1 Scoping Review

The following strength was identified in the scoping review:

- Quality Analysis was executed using the AMSTAR-2 tool for included systematic reviews. Quality analysis is not usually included in the scoping review and thus further informs the readers confidence in the summarized results of the systematic review.
- Study selection had occurred by two reviewers. Two reviewers were involved in the study selection process to ensure the minimization of the risk of error.

4.4.2 Primary Study

The following strength was identified in the Primary Study:

- Excellent Intra-rater reliability was identified, for the tools measuring grip strength, maximal inspiratory pressure, and peripheral muscle strength. This is seen as a strength as it further supports the consistency in the execution of testing.

4.5 Conclusion

Our thesis has described age and gender specific normative reference values for clinical field tests used daily in primary based rehabilitation. These reference values were specific to a sampled population of a resource-restrained metropolitan area in Cape Town, South Africa. An insight to the 'normal' variation of muscle strength, grip strength, respiratory strength and exercise capacity is now presented. Our reference values differed greatly when compared to international reference values for the same five clinical field tests. International reference values need to be approached with caution in a South African clinical context. The development of South African normative reference values for clinical field tests could aid decision making by clinicians at Primary Health Care (PHC) level.

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6 Addenda

6.1 Addendum A: Ethical Approval

UNIVERSITEIT STELLENBOSCH UNIVERSITY

Approval Notice

New Application

05/02/2020

Project ID :10811

HREC Reference No: S19/10/219

Project Title: The validity of reference values for five clinical field tests used in primary health care rehabilitation in a resource restrained South African Metropolitan context

Dear Mr. Kamir Baldeo

The **New Application** received on 12/12/2019 16:04 was reviewed by members of **Health Research Ethics Committee** via **expedited** review procedures on 05/02/2020 and was approved.

Please note the following information about your approved research protocol:

Protocol Approval Date: 05 February 2020

Protocol Expiry Date: 04 February 2021

Please remember to use your Project ID 10811 and Ethics Reference Number S19/10/219 on any documents or correspondence with the HREC concerning your research protocol.

Please note that the HREC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

After Ethical Review

Translation of the informed consent document(s) to the language(s) applicable to your study participants should now be submitted to the HREC.

Please note you can submit your progress report through the online ethics application process, available at: Links Application Form Direct Link and the application should be submitted to the HREC before the year has expired. Please see *Forms and Instructions* on our HREC website (www.sun.ac.za/healthresearchethics) for guidance on how to submit a progress report.

The HREC will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly for an external audit.

Provincial and City of Cape Town Approval

Please note that for research at a primary or secondary healthcare facility, permission must still be obtained from the relevant authorities (Western Cape Department of Health and/or City Health) to conduct the research as stated in the protocol. Please consult the Western Cape Government website for access to the online Health Research Approval Process, see: https://www.westerncape.gov.za/general-publication/health-research-approval-process. Research that will be conducted at any tertiary academic institution requires approval from the relevant hospital manager. Ethics approval is required BEFORE approval can be obtained from these health authorities.

We wish you the best as you conduct your research.

For standard HREC forms and instructions, please visit: Forms and Instructions on our HREC website https://applyethics.sun.ac.za/ProjectView/Index/10811

If you have any questions or need further assistance, please contact the HREC office at 021 938 9677.

Yours sincerely,

Ms Elvira Rohland
Health Research Ethics Committee 2 (HREC2)

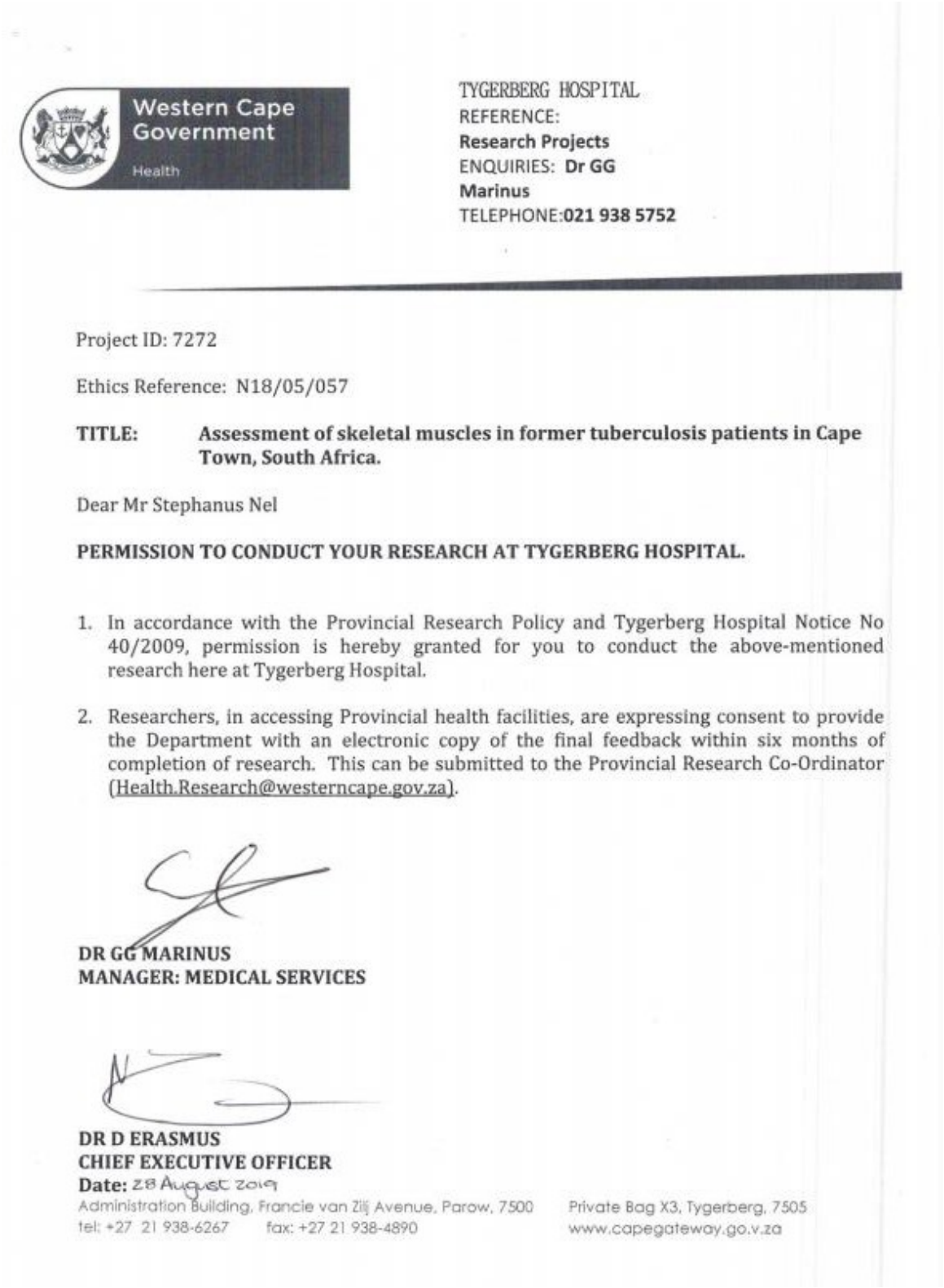
National Health Research Ethics Council (NHREC) Registration Number:

REC-130408-012 (HREC1)•REC-230208-010 (HREC2)

Federal Wide Assurance Number: 00001372

6.2 Addendum B: Institutional Approval

The thesis forms part of a larger study thus gained insitutional approval under the larger study.



Western Cape Government
Health

TYGERBERG HOSPITAL
REFERENCE:
Research Projects
ENQUIRIES: **Dr GG Marinus**
TELEPHONE:**021 938 5752**

Project ID: 7272

Ethics Reference: N18/05/057

TITLE: **Assessment of skeletal muscles in former tuberculosis patients in Cape Town, South Africa.**

Dear Mr Stephanus Nel

PERMISSION TO CONDUCT YOUR RESEARCH AT TYGERBERG HOSPITAL.

1. In accordance with the Provincial Research Policy and Tygerberg Hospital Notice No 40/2009, permission is hereby granted for you to conduct the above-mentioned research here at Tygerberg Hospital.

2. Researchers, in accessing Provincial health facilities, are expressing consent to provide the Department with an electronic copy of the final feedback within six months of completion of research. This can be submitted to the Provincial Research Co-Ordinator (Health.Research@westerncape.gov.za).

DR GG MARINUS
MANAGER: MEDICAL SERVICES

DR D ERASMUS
CHIEF EXECUTIVE OFFICER
Date: 28 August 2019

Administration Building, Francie van Zijl Avenue, Parow, 7500 Private Bag X3, Tygerberg, 7505
tel: +27 21 938-6267 fax: +27 21 938-4890 www.capegateway.go.v.za

6.3 Addendum C: Intention to Submit

NOTICE OF INTENTION TO SUBMIT THESIS/DISSERTATION FOR EXAMINATION

DOCTORAL OFFICE / DOKTORALE KANTOOR

Name of student	Kamir Baldeo
Student number	17791669
Degree programme	MSc Physiotherapy (THESIS)
Title of thesis/dissertation	'The validity of reference values for five clinical field tests used in primary health care rehabilitation in a resource restrained South African Metropolitan context'
Year of first registration	2019
Department	Physiotherapy
Supervisor	Professor S Hanekom
Co-supervisor *(if applicable)*	Mr Stephan Nel
Examiners approved at KNN	

I hereby give notice that I intend to submit my thesis/dissertation in time for the:
December Graduation 2020

MASTERS:

- 1 September for December graduation 20…
- 1 December for April graduation 20…

DOCTORAL:

- 1 August for December graduation 20…
- 15 October for March graduation 20…

I confirm that I have taken note of the closing date for handing in my thesis

26/02/2020

Signature

Date

Project ID: 7272

Ethics Reference: N18/05/057

TITLE: **Assessment of skeletal muscles in former tuberculosis patients in Cape Town, South Africa.**

BY 

An authorized representative of Tygerberg Hospital

NAME Dr DS Erasmus

TITLE CEO

DATE 28 August 2019

6.4 Addendum D: Participant Information Leaflet and Consent Form in English

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

TITLE OF THE RESEARCH PROJECT:

'The validity of reference values for five clinial field tests used in primary health care rehabilitation in a resource restrained South African Metropolitan context.'

REFERENCE NUMBER:

PRINCIPAL INVESTIGATOR: Kamir Baldeo

ADDRESS: Stellenbosch University

Faculty of Medicine and Health Sciences

Division of Physiotherapy

Francie van Zijl Drive

Tygerberg

7505

Cape Town

South Africa

CONTACT NUMBER: 0746397191

You are being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask the study staff any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand

what this research entails and how you could be involved. Also, your participation is entirely voluntary and you are free to not to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the Health Research Ethics Committee at Stellenbosch University and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.

What is this research study all about?

The study will be conducted at *. By doing this study, we would like to determine the results of clinical field tests used in physiotherapy used to determine the strength of the muscles you use to breathe in oxygen, your capacity to perform functional exercises, strength of your upper limbs and lower limbs and quality of life. The aim of the study is to identify the normative outcomes of these clinical tests in an apparently healthy person.

Why have you been invited to participate?

You've been invited to take part in this study because you reside in a metropolitan area in South Africa.

What will your responsibilities be?

You do not have any responsibility except for participating in the study, should you agree.

Will you benefit from taking part in this research?

You might not receive any personal benefits from this study, but by taking part we could gain information regarding normal muscle strength, exercise capacity and quality of life. This might assist us in the future management of patients in need of rehabilitation.

Are there any risks involved in your taking part in this research?

The tests to see how well the muscles of your legs, arms and hands function might cause some discomfort. The test to see how well your breathing muscle are working may make you feel dizzy and make you feel out of breath. The walking test might make your heart beat a little faster and feel out of breath or make your leg muscles tired.

If you do not agree to take part, what alternatives do you have?

If you do not want to take part in this study, you are free to leave at any time.

Who will have access to the information that we recorded?

We will remove all information which can be used to identify you, so no-one will know that the information we collect is yours.

What will happen in the unlikely event of some form injury occurring as a direct result of your taking part in this research study?

In the very unlikely event of an injury that is the direct result of your taking part in this study Stellenbosch University has insurance that would cover any expenses or losses that you would suffer.

Will you be paid to take part in this study and are there any costs involved?

No, you will not be paid to take part in the study. There will be no costs involved for you, if you do take part.

Can we contact you for future research?

Can we contact you to invite you to participate in future studies?

Yes_____ No_____

Is there anything else that you should know or do?

You can contact the Researcher, Kamir Baldeo; on 0746397191 should you need more information regarding the study.

You can contact the Health Research Ethics Committee at 021-938 9207 if you have any concerns or complaints that have not been adequately addressed by the researchers.

You will receive a copy of this information and consent form for your own records.

Declaration by participant

By signing below, I …….. agree to take part in a research study entitled "The validity of reference values for five clinial field tests used in primary health care rehabilitation in a resource restrained South African Metropolitan context ."

I declare that:

• I have read or had read to me this information and consent form and it is written in a language with which I am fluent and comfortable.

• I have had a chance to ask questions and all my questions have been adequately answered.

• I understand that taking part in this study is voluntary and I have not been pressurized to take part.

• I may choose to leave the study at any time and will not be penalized or prejudiced in any way.

• I may be asked to leave the study before it has finished, if the study doctor or researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (place) …….. on (date) …….. 2019

…….. ……..

Signature of participant Signature of witness

Declaration by investigator

I (name) …… declare that:

• I explained the information in this document to ……

• I encouraged him/her to ask questions and took adequate time to answer them.

• I am satisfied that he/she adequately understands all aspects of the research,

as discussed above

• I did/did not use an interpreter. (If an interpreter is used then the interpreter

must sign the declaration below.

Signed at (place) ……..…… on (date) ……..…… 2019

…….. ……..

Signature of investigator Signature of witness

Declaration by interpreter

I (name) …… declare that:

• I assisted the investigator (name) …….. to explain

the information in this document to (name of participant)

…….. using the language medium of

Afrikaans/Xhosa.

• We encouraged him/her to ask questions and took adequate time to answer

them.

• I conveyed a factually correct version of what was related to me.

• I am satisfied that the participant fully understands the content of this informed

consent document and has had all his/her question satisfactorily answered.

Signed at (place) …… on (date) ……..……..

…….. ……..

Signature of interpreter Signature

6.5 Addendum E : Participant Information Leaflet and Consent Form in Afrikaans

DEELNEMERINLIGTINGSBLAD EN -TOESTEMMINGSVORM

TITEL VAN DIE NAVORSINGSPROJEK:

'Die geldigheid van verwysingswaardes vir vyf kliniese veldtoetse wat gebruik word in primêre gesondheidsorg rehabilitasie binne ń Suid-Afrikaanse stedelike konteks met beperkte hulpbronne.'

VERWYSINGSNOMMER:

HOOFNAVORSER: Kamir Baldeo

ADRES:

Stellenbosch Universitiet
Fakulteit Geneeskunde en Gesondheidswetenskappe
Afdeling Fisioterapie
Francie van Zijl Rylaan
Tygerberg
7505
Kaapstad
Suid Afrika

KONTAKNOMMER: 0746397191

U word genooi om deel te neem aan 'n navorsingsprojek. Lees asseblief hierdie inligtingsblad op u tyd deur aangesien die detail van die navorsingsprojek daarin verduidelik word. Indien daar enige deel van die navorsingsprojek is wat u nie ten volle verstaan nie, is u welkom om die navorsingspersoneel of dokter daaroor uit te vra. Dit is baie belangrik dat u ten volle moet verstaan wat die navorsingsprojek behels en hoe u daarby betrokke kan wees. U deelname is ook **volkome vrywillig** en dit staan u vry om deelname te weier. U sal op geen wyse hoegenaamd negatief beïnvloed word indien u sou weier om deel te neem nie. U mag ook te eniger tyd aan die navorsingsprojek onttrek, selfs al het u ingestem om deel te neem.

Hierdie navorsingsprojek is deur die **Gesondheidsnavorsingsetiekkomitee (GNEK) van die Universiteit Stellenbosch** goedgekeur en sal uitgevoer word volgens die etiese riglyne en beginsels van die Internasionale Verklaring van Helsinki en die Etiese Riglyne vir Navorsing van die Mediese Navorsingsraad (MNR).

Wat behels hierdie navorsingsprojek?

Hierdie studie sal by * uitgevoer word. Ons wil hierdie studie gebruik om die resultate te bepaal van kliniese veld toetse wat deur fisioterapeute gebruik word om jou inasem spierkrag, jou vermoë om oefening te doen, jou ledemaat spierkrag en jou kwaliteit van lewe te toets. Die doelwit van die studie is om die normale waardes van hierdie kliniese veld toetse in gesonde mense te bepaal.

Waarom is u genooi om deel te neem?

U is uitgenooi om deel te neem aan hierdie studie omdat u afkomstig is van ń stedelike gebied in Suid-Afrika.

Wat sal u verantwoordelikhede wees?

Ons gaan van u verwag om vrae te beantwoord oor u werk, rook geskiedenis, alkohol gebruik, ander mediese kondisies en u kwaliteit van lewe. Ons gaan ook toetse doen om te sien hoe goed u spiere werk. Tydens hierdie spier toetse gaan u so hard as moontlik teen ‘n meetinstrument moet stoot met u been, arm en hand. Om u asemhalings spiere te toets gaan u deur ‘n toestel, wat weerstand bied, moet suig so hard as wat u kan. U kapasiteit om oefening te doen gaan getoets word deur te meet hoe ver u kan stap in ses minute.

Sal u voordeel trek deur deel te neem aan hierdie navorsingsprojek?

U gaan geen direkte voordeel put nie. Hierdie studie sal ons egter help om meer te leer van normale spierkrag, oefen kapasiteit en kwaliteit van lewe. Dit kan ons moontlik help om die hantering van toekomstige pasiënte wat rehabilitasie nodig het te verbeter.

Is daar enige risiko's verbonde aan u deelname aan hierdie navorsingsprojek?

Die spierfunksie toetse van u bene en arms mag dalk ongemaklik wees en die spiere moeg maak. Die toetse van u asemhalings spiere mag u dalk duiselig maak en uitasem laat voel. Die stap toetse mag u moontlik uit asem laat voel en u beenspiere moeg maak.

Watter alternatiewe is daar indien u nie instem om deel te neem nie?

U mag enige tyd kies om nie meer deel te wees van die studie nie.

Wie sal toegang hê tot die informasie wat ons ingesamel het?

Alle informasie wag gebruik kan word om u identiteit te bepaal sal verwyder word sodat niemand die informasie wat ingesamel word met u kan verbind nie.

Wat sal gebeur in die onwaarskynlike geval van 'n besering wat mag voorkom as gevolg van u deelname aan hierdie navorsingsprojek?

Indien u beseer word tydens deelname aan hierdie studie, wat baie onwaarskynlik is, sal alle kostes en verliese gedek word. Stellenbosch Universiteit het versekering in plek daarvoor.

Sal u betaal word vir deelname aan die navorsingsprojek en is daar enige koste verbonde aan deelname?

U sal nie betaal word vir u deelname nie. Daar is geen kostes aan u om deel te neem nie.

Kan ons u in die toekoms kontak vir verdere navorsing?

Kan ons u kontak en uitnooi om deel te neem aan moontlike toekomstige studies?

Ja____ Nee____

Is daar enigiets anders wat u moet weet of doen?

- U kan Kamir Baldeo kontak by 0746397191 indien u enige verdere vrae het of enige probleme ondervind.
- U kan die **Gesondheidsnavorsingsetiek administrasie** kontak by 021 938 9207 indien u enige bekommernis of klagte het wat nie bevredigend deur u studiedokter hanteer is nie.

- U sal 'n afskrif van hierdie inligtings- en toestemmingsvorm ontvang vir u eie rekords.

Verklaring deur deelnemer

Met die ondertekening van hierdie dokument onderneem ek, ……., om deel te neem aan 'n navorsingsprojek getiteld: 'Verwysings waardes vir vyf kliniese veld toetse wat gebruik word in primêre gesondheidsorg rehabilitasie binne ń Suid-Afrikaanse Stedelike konteks met beperkte hulpbronne.'

Ek verklaar dat:

•Ek hierdie inligtings- en toestemmingsvorm gelees het of aan my laat voorlees het en dat dit in 'n taal geskryf is waarin ek vaardig en gemaklik mee is.
•Ek geleentheid gehad het om vrae te stel en dat al my vrae bevredigend beantwoord is.
•Ek verstaan dat deelname aan hierdie navorsingsprojek vrywillig is en dat daar geen druk op my geplaas is om deel te neem nie.
•Ek te eniger tyd aan die navorsingsprojek mag onttrek en dat ek nie op enige wyse daardeur benadeel sal word nie.
•Ek gevra mag word om van die navorsingsprojek te onttrek voordat dit afgehandel is indien die studiedokter of navorser van oordeel is dat dit in my beste belang is, of indien ek nie die ooreengekome navorsingsplan volg nie.

Geteken te (plek) …….. op (datum) …….. 2019.

Handtekening van deelnemer **Handtekening van getuie**

Verklaring deur navorser

Ek (naam) ……..…… verklaar dat:

•Ek die inligting in hierdie dokument verduidelik het aan ……..……..

•Ek hom/haar aangemoedig het om vrae te vra en voldoende tyd gebruik het om dit te beantwoord.

•Ek tevrede is dat hy/sy al die aspekte van die navorsingsprojek soos hierbo bespreek, voldoende verstaan.

•Ek 'n tolk gebruik het/nie 'n tolk gebruik het nie. (Indien 'n tolk gebruik is, moet die tolk die onderstaande verklaring teken.)

Geteken te (plek) ……..…….. op (datum) ……..…….. 2019.

Handtekening van navorder **Handtekening van getuie**

Verklaring deur tolk

Ek (naam) ……..…… verklaar dat:

•Ek die navorser (naam) ……..…….. bygestaan het om die inligting in hierdie dokument in Afrikaans/Xhosa aan (naam van deelnemer) ……..…….. te verduidelik.

•Ons hom/haar aangemoedig het om vrae te vra en voldoende tyd gebruik het om dit te beantwoord.

•Ek 'n feitelik korrekte weergawe oorgedra het van wat aan my vertel is.

•Ek tevrede is dat die deelnemer die inhoud van hierdie dokument ten volle verstaan en dat al sy/haar vrae bevredigend beantwoord is.

Geteken te (plek) ……..…….. op (datum) ……..…….. 2019.

Handtekening van tolk **Handtekening van getuie**

6.6 Addendum F : Participant Information Leaflet and Consent Form in Xhosa

INCWADANA YEENKCUKACHA NGOMTHATHI-NXAXHEBA KUNYE NEFOMU YEMVUME

ISIHLOKO SEPROJEKTHI YOPHANDO:
UVAVANYO LWEZIHLUNU ZOMZIMBA KWIZIGULANE EBEZINESIFO SEPHEPHA, EKAPA, EMZANTSI AFRIKA

INOMBOLO YONXULUMANO:

UMPHANDI OYINTLOKO:
Kamir Baldeo

IDILESI:
Education building room 4100
Stellenbosch University
Faculty of Medicine and Health Sciences
Division of Physiotherapy
Francie van Zijl Drive
Tygerberg
7505
Cape Town
South Africa

INOMBOLO YOQHAGAMSHELWANO:
0746397191

Uyamenywa ekuthatheni inxaxheba kwiprojekthi yophando. Nceda uthathe ixesha lokufunda ulwazi oluchazwe apha, noluyakuthi lucacise iinkcukacha zale projekthi. Nceda ubuze kugqirha okanye kubasebenzi bophononongo nayiphi na imibuzo emalunga nantoni na eyinxalenye yale projekthi ongayiqondi kakuhle. Kubalulekile ukuba uthi kanti woneliseke ngokupheleleyo kwanokuba ukuqonda ngokucacileyo okuqulathwe kolu phando nendlela onokuzibandakanya

ngayo. Ukongeza, uthatha inxaxheba **ngokuzithandela ngokuphele leyo** kwaye wamkelekile ukuba ungala ukuthatha inxaxheba. Ukuba uthi hayi, oku akusayi kuchaphazela wena ngendlela engafanelekanga nangayiphi na indlela. Ungarhoxa kuphononongo ngokukhululekileyo nanini na, nokuba awuvumi ukuthatha inxaxheba.

Olu phononongo luvunywe **yiKomiti yeeNqobo eziSesikweni zoPhando lwezeMpilo yeYunivesithi yaseStellenbosch** kwaye luya kukhokelwa ngokuhambelana nezikhokelo zeenqobo ezisesikweni kunye nemimiselo yesiBhengenzo seHlabathi saseHelsinki, iziKhokelo zaseMzantsi Afrika zoKwenziwa koMsebenzi wezoNyango ngokuFanelekileyo kunye neziKhokelo zeeNqobo eziSesikweni zeBhunga loPhando lwamaYeza kwezoPhando (MRC).

Simalunga nantoni esi sifundo sophando?

Uphononongo luya kuqhutywa *. Ngokwenza esi sifundo, sifuna ukucacisa iziphumo zeemvavanyo zentsimi yekliniki ezisetyenziswe kwi-physiotherapy esetyenziselwa ukuchonga amandla ezihlunu ozisebenzisayo ukuphefumla oksijini, amandla akho okwenza umsebenzi osebenzayo, amandla akho ezinyathelo ezingaphezulu kunye namagqabana aphantsi, umsebenzi womzimba kunye nomgangatho wobomi. Injongo yesifundo kukufumanisa iziphumo eziqhelekileyo zezi mvavanyo zekliniki kumntu obonakala enempilo.

Kutheni umenyiwe ukuba uthathe inxaxheba?

Umenywe ukuba uthathe inxaxheba kulolu cwaningo ukubonelela ngexabiso eliqhelekileyo lokubaluleka kwi-five field field test.

Luyakuba yintoni uxanduva lwakho?

Awunayo nayiphi na imfanelo ngaphandle kokuba uthathe inxaxheba kwisifundo, ukuba uyavuma.

Ingaba uza kuzuza ekuthatheni inxaxheba kolu phando?

Akunakufumana naziphi na izibonelelo ezivela kulolu cwaningo, kodwa ngokuthatha inxaxheba unokufumana ulwazi malunga namandla akho omzimba kunye nokusebenzisa amandla.

Ingaba zikho iingozi ezibandakanyekayo ekuthatheni kwakho inxaxheba kolu phando?

Umngcipheko kuphela ongenzekayo kukuba unokufumana uxinzelelo lwegazi lokungena phantsi okanye ukwanda kwimixinzelelo yegazi. Ukuba oku kufuneka kwenzeke, isifundo siya kumiswa, kwaye uya kuncedwa ngokufanelekileyo. Uya kufumana inamba yenzalo yophando ukuze ubume bakho bungabonakali. Xa iziphumo zolu phando zipapashwa kwiphepha lezonyango, igama lakho alize likhankanywe.

Kuza kwenzeka ntoni kwimeko yesiganeko esingalindelekanga sokwenzakala ngenxa yokuthatha kwakho inxaxheba kolu phononongo lophando?

Uya kuhlolisiswa rhoqo kulo lonke uphando. Ngaba uxinzelelo lwegazi lakho ukulahla ngexesha lokuvavanya, uya kuthunyelwa ngokufanelekileyo ukuze ufune unyango olufunekayo.

Ingaba uza kuhlawulwa ngokuthatha inxaxheba kolu phononongo kwaye ingaba kukho iindleko ezibandakanyekayo?

Hayi, awuyi kuhlawulwa ukuba uthathe inxaxheba kwisifundo. Ngeke kubekho iindleko ezichaphazelekayo kuwe, ukuba uthatha inxaxheba.

Ingaba ikho enye into ekumele uyazi okanye uyenze?

- Ungaqhagamshelana noKamir Baldeo uNombolo 0746397191 ukubangaba uneminye imibuzo onayo okanye naziphina iingxaki ozifumanayo.
- Ungaqhagamshelana neKomiti yoPhando Lomntu kwa-021-938 9207 ukuba unenkxalabo okanye izikhalazo ezingasonjululwanga kakuhle ngugqirha wakho wophononongo.
- Uza kufumana ikopi yolu lwazi kunye nefomu yesivumelwano ukwenzela iingxelo zakho.

Isifungo somthathi-nxaxheba

Ngokutyikitya ngezantsi, Mna …………………………………………………… ndiyavuma ukuthatha inxaxheba koluphononongo lophando semfuzo esibizwa ngokuba:
"UVAVANYO LWEZIHLUNU ZOMZIMBA KWIZIGULANE EBEZINESIFO SEPHEPHA, EKAPA, EMZANTSI AFRIKA"

Ndazisa ukuba:

- Ndilufundile okanye ndalufunda olu lwazi kunye nefomu yemvume kwaye ibhalwe ngolwimi endiliciko nendikhululekileyo kulo
- Bendinalo ithuba lokuba ndibuze imibuzo kwaye yonke imibuzo yam iphendulwe ngokwanelisayo.
- Ndiyakuqonda ukuba ukuthatha inxaxheba kolu phando kube **kukuzithandela kwam** kwaye andikhange ndinyanzelwe ukuba ndithathe inxaxheba.
- Ndingakhetha ukusishiya isifundo naninina kwaye andisayi kohlwaywa okanye uqal'ugwetywe nangayiphi indlela.
- Usenokucelwa ukuba uyeke kuphononongo ngaphambi kokuba luphele, ukuba ugqirha wophononongo okanye umphandi ukubona kuyinzuzo kuwe, okanye ukuba andisilandeli isicwangciso sesifundo, ekuvunyelenwe ngaso.

Kutyikitywe e-(indawo) ……………………………… ngo-(usuku) …………………… 2019.

……………………………………………………… ………………………………………………………

Utyikityo lomthathi-nxaxheba **Utyikityo lwengqina**

Isifungo somphandi

Mna *(igama)* …………………………………………………… ndiyafunga ukuba:

- Ndilucacisile ulwazi olu kolu xwebhu ku-…………………………………..
- Ndimkhuthazile ukuba abuze imibuzo kwaye athathe ixesha elifanelekileyo ukuba ayiphendule.
- Ndiyaneliseka kukuba uyakuqonda ngokwanelisayo konke okumalunga nophando okuxoxwe ngasentla.
- Ndisebenzise/andisebenzisanga toliki. (*Ukuba itoliki isetyenzisiwe kumele ityikitye isaziso esingezantsi.)*

Sityikitywe e-(indawo) ………………………………. ngo-(usuku) ……………………. 2019.

………………………………………………………………… ………………………………………………………………

Utyikityo lomphandi **Utyikityo lwengqina**

Isifungo setoliki

Mna (igama) …… ndazisa ukuba:

•Ndicende umphandi (igama) …… Ekucaciseni ulwazi olu lapha kolu xwebhu ku-(igama lomthathi-nxaxheba) …….. ndisebenzisa ulwimi lwesiAfrikaans lwesiXhosa.

•Simkhuthazile ukuba abuze imibuzo kwaye athathe ixesha elifanelekileyo ukuba ayiphendule.

•Ndimxelele eyona nto iyiyo malunga nokunxulumene nam.

•Ndiyaneliseka kukuba umthathi-nxaxheba ukuqonda ngokupheleleyo okuqulathwe loluxwebhu lwemvumeeyazisiweyo kwaye nemibuzo yakhe yonke iphendulwe ngokwanelisayo.

Sityikitywe e-(indawo) …….. ngo-(usuku) …….. 2019.

Utyikityo lwetoliki **Utyikityo lwengqina**

6.7 Addendum G: Redcap Data Collection Tool

Confidential

Screening tool

Record ID	_____
Date	_____
Time	_____
Age	_____
Any current or previous history of TB	☐ Current history of TB ☐ Previous history of TB
Does the participant meet the following inclusion cirteria?	☐ Adults (over 18 years of age) ☐ Written informed consent ☐ No history of TB (Please tick the relevant box)
Does the participant meet the following exclusion criteria?	☐ Patients presenting with signs and symptoms of undiagnosed TB ☐ Pregnancy ☐ Adults above the age of 65 ☐ Unable to perform exercise capacity assessment (6MWT) due to contraindications according to the ERS/ATS technical standards.(Issues et al., 2002) ☐ Disability that prevents participant from partaking in physical activity. ☐ Inability to perform respiratory muscles function tests or present with a condition that is contraindicative to respiratory muscle function tests: ☐ A resting pulse rate of more than 120 beats/minute. ☐ A myocardial infarction in the last 3 months ☐ Any major surgical procedure in the last month ☐ Co-morbidities that may affect the outcome of the test and may have a negative outcome to the participant ☐ abdominal or eye surgery in the last 3 months. (Please tick the relevant box)
Have you had any of the following medical conditions?	☐ Stroke ☐ Heart trouble according to your Dr. ☐ Asthma ☐ Cancer ☐ Osteoporosis ☐ severe arthritis ☐ muscle degeneration/weakness ☐ Liver disease ☐ Kidney disease ☐ Endocrine disorders

Have you had any of the following signs/symptoms?	☐ pain in your heart, chest or surrounding areas, particularly during exercise? ☐ feel faint or have spells of dizziness during exercise? ☐ unusual fatigue or shortness of breath at rest or with mild exertion? ☐ shortness of breath that comes on after you stopped exercise? ☐ awakened at night by an attack of shortness of breath? ☐ swelling or accumulation of fluid in or around your ankles? ☐ your heart is beating too fast, racing, skipping beats, either at rest or during exercise? ☐ pains in your calves and lower legs during exercise that are not due to soreness or stiffness? ☐ Has your doctor ever told you that you have a heart murmur?
Informed Consent Obtained	○ Yes ○ No
If no, why?	_____

Station 1 Active 6MWT 1

Record ID	_____
Date	_____ ((D-M-Y))
Time	_____
Blood Pressure (SBP/DBP) mmHG	_____ (Patient seated at start in sitting position for atleast 10 minutes prior to start:)
Heart rate at baseline	_____
Oxygen Saturation SpO2	_____
Rate baseline dyspnea and overall fatigue according to the Borg scale	☐ 0 Nothing at all ☐ 0.5 Very, very slight (just noticeable) ☐ 1 Very slight ☐ 2 Slight (light) ☐ 3 Moderate ☐ 4 Somewhat severe ☐ 5 Severe (heavy) ☐ 6 ☐ 7 Very severe ☐ 8 ☐ 9 ☐ 10 (Patient takes up standing position)
6MWT 1 Distance	_____ ((Laps X distance(30m)) + additional m in last lap)
Post 6MWT Blood Pressure (SBP/DBP) mmHG	_____
Post 6MWT Heart rate	_____
Post 6MWT Oxygen Saturation SpO2	_____

Post 6MWT Rate baseline dyspnea and overall fatigue according to the Borg scale	☐ 0 Nothing at all ☐ 0.5 Very, very slight (just noticeable) ☐ 1 Very slight ☐ 2 Slight (light) ☐ 3 Moderate ☐ 4 Somewhat severe ☐ 5 Severe (heavy) ☐ 6 ☐ 7 Very severe ☐ 8 ☐ 9 ☐ 10
Heart rate one minute post 6MWT 1	_____
Saturation one minute post 6MWT 1	_____
One minute post 6MWT Rate baseline dyspnea and overall fatigue according to the Borg scale	☐ 0 Nothing at all ☐ 0.5 Very, very slight (just noticeable) ☐ 1 Very slight ☐ 2 Slight (light) ☐ 3 Moderate ☐ 4 Somewhat severe ☐ 5 Severe (heavy) ☐ 6 ☐ 7 Very severe ☐ 8 ☐ 9 ☐ 10
Comments 6MWT1 Reasons for resting etc.	_____

Station 1 Active 6MWT 2

Record ID	_____
Date	_____ ((D-M-Y))
Time	_____
Blood Pressure (SBP/DBP) mmHG	_____ (Patient seated at start in sitting position for atleast 10 minutes prior to start:)
Heart rate at baseline	_____
Oxygen Saturation SpO2	_____
Rate baseline dyspnea and overall fatigue according to the Borg scale	☐ 0 Nothing at all ☐ 0.5 Very, very slight (just noticeable) ☐ 1 Very slight ☐ 2 Slight (light) ☐ 3 Moderate ☐ 4 Somewhat severe ☐ 5 Severe (heavy) ☐ 6 ☐ 7 Very severe ☐ 8 ☐ 9 ☐ 10 (Patient takes up standing position)
6MWT 2 Distance	_____ ((Laps X distance(30m)) + additional m in last lap)
Post 6MWT 2 Blood Pressure (SBP/DBP) mmHG	_____
Post 6MWT 2 Heart rate	_____
Post 6MWT 2 Oxygen Saturation SpO2	_____

Post 6MWT 2 Rate baseline dyspnea and overall fatigue according to the Borg scale	☐ 0 Nothing at all ☐ 0.5 Very, very slight (just noticeable) ☐ 1 Very slight ☐ 2 Slight (light) ☐ 3 Moderate ☐ 4 Somewhat severe ☐ 5 Severe (heavy) ☐ 6 ☐ 7 Very severe ☐ 8 ☐ 9 ☐ 10
Heart rate one minute post 6MWT 2	_____
Saturation one minute post 6MWT 2	_____
One minute post 6MWT 2 Rate baseline dyspnea and overall fatigue according to the Borg scale	☐ 0 Nothing at all ☐ 0.5 Very, very slight (just noticeable) ☐ 1 Very slight ☐ 2 Slight (light) ☐ 3 Moderate ☐ 4 Somewhat severe ☐ 5 Severe (heavy) ☐ 6 ☐ 7 Very severe ☐ 8 ☐ 9 ☐ 10
Comments 6MWT2 Reasons for resting etc.	_____
Best of the two 6MWT taken	_____

Station 2 Non-active

Record ID	_____
Date	_____
Time	_____
Gender	☐ Male ☐ Female
Age Group	☐ 18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56-65
height	_____ ((cm))
weight	_____ ((Kg))
BMI (Body Mass Index)	_____
Please select the relevant BMI category	☐ Underweight < 18.50 ☐ Healthy Weight Range 18.50 - 24.99 ☐ Overweight 25.00 - 29.99 ☐ Obese 30 or more
Area in which you reside	_____
Are you currently employed?	◯ Yes ◯ No
If yes, what is your occupation?	_____
Do you have any co-morbidities?	◯ Yes ◯ No
If yes, what are they?	◯ Yes ◯ No (Eg) Hypertension, Cholesterol, Diabetes etc.)
Do you currently use any medication?	◯ Yes ◯ No

If yes, what are they and how often?

_____

Please list any dietary/energy supplements you take?

_____

Do you smoke?

○ Yes
○ No

If yes, How many a day?

_____

Do you have any mental health disorders?

○ Yes
○ No

If yes, what are they?

Eg) mood, anxiety, psychotic disorders?

_____

Do you currently have any acute conditons?

Eg) Influenza, sinusitis, headaches etc.

○ Yes
○ No

If yes, what are they?

_____

Do you exercise regularly?

○ Yes
○ No

If yes, how often?

_____
(Times per week)

What exercises do you do?

_____

Station 3 Active

Record ID	_____
Date	_____
Time	_____
Dominant Upper Limb	○ Left ○ Right
Left shoulder abduction 1	_____
Left shoulder abduction 2	_____
Left shoulder abduction 3	_____
Best of three taken	_____
Right shoulder abduction 1	_____
Right shoulder abduction 2	_____
Right shoulder abduction 3	_____
Best of three taken	_____
Dominant lower limb	○ Left ○ Right
Left knee extension 1	_____
Left knee extension 2	_____
Left knee extension 3	_____
Best of three taken	_____

Right knee extension 1	_____
Right knee extension 2	_____
Right knee extension 3	_____
Best of three taken	_____

Station 4 Non-Active

Record ID _____

MOBILITY

- ○ I have no problems in walking about
- ○ I have slight problems in walking about
- ○ I have moderate problems in walking about
- ○ I have severe problems in walking about
- ○ I am unable to walk about

Please click the ONE box that best describes your health TODAY.

SELF-CARE

- ○ I have no problems washing or dressing myself
- ○ I have slight problems washing or dressing myself
- ○ I have moderate problems washing or dressing myself
- ○ I have severe problems washing or dressing myself
- ○ I am unable to wash or dress myself

Please click the ONE box that best describes your health TODAY.

USUAL ACTIVITIES (e.g. work, study, housework, family or leisure activities)

- ○ I have no problems doing my usual activities
- ○ I have slight problems doing my usual activities
- ○ I have moderate problems doing my usual activities
- ○ I have severe problems doing my usual activities
- ○ I am unable to do my usual activities

Please click the ONE box that best describes your health TODAY.

PAIN / DISCOMFORT

- ○ I have no pain or discomfort
- ○ I have slight pain or discomfort
- ○ I have moderate pain or discomfort
- ○ I have severe pain or discomfort
- ○ I have extreme pain or discomfort

Please click the ONE box that best describes your health TODAY.

ANXIETY / DEPRESSION

- ◯ I am not anxious or depressed
- ◯ I am slightly anxious or depressed
- ◯ I am moderately anxious or depressed
- ◯ I am severely anxious or depressed
- ◯ I am extremely anxious or depressed

We would like to know how good or bad your health is TODAY.

This scale is numbered from 0 to 100.

100 means the best health you can imagine.
0 means the worst health you can imagine.
Please click on the scale to indicate how your health is TODAY.

0 - The worst health you can imagine

50

100 - The best health you can imagine

(Place a mark on the scale above)

Station 5 Active

Record ID	_____
Date	_____
Time	_____
MIP 1	_____
MIP 2	_____
MIP 3	_____
Best of three taken	_____
Which hand is your dominant hand ?	○ Left ○ Right
Left grip strength 1	_____
Left grip strength 2	_____
Left grip strength 3	_____
Best of three taken	_____
Right grip strength 1	_____
Right grip strength 2	_____
Right grip strength 3	_____
Best of three taken	_____

6.8 Addendum H: AMSTAR-2 Critical Appraisal Tool

AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both

1. Did the research questions and inclusion criteria for the review include the components of PICO?

For Yes:	Optional (recommended)	
☐ Population ☐ Intervention ☐ Comparator group ☐ Outcome	☐ Timeframe for follow-up	☐ Yes ☐ No

2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?

For Partial Yes: The authors state that they had a written protocol or guide that included ALL the following:	For Yes: As for partial yes, plus the protocol should be registered and should also have specified:	
☐ review question(s) ☐ a search strategy ☐ inclusion/exclusion criteria ☐ a risk of bias assessment	☐ a meta-analysis/synthesis plan, if appropriate, *and* ☐ a plan for investigating causes of heterogeneity ☐ justification for any deviations from the protocol	☐ Yes ☐ Partial Yes ☐ No

3. Did the review authors explain their selection of the study designs for inclusion in the review?

For Yes, the review should satisfy ONE of the following:	
☐ *Explanation for* including only RCTs ☐ OR *Explanation for* including only NRSI ☐ OR *Explanation for* including both RCTs and NRSI	☐ Yes ☐ No

4. Did the review authors use a comprehensive literature search strategy?

For Partial Yes (all the following):	For Yes, should also have (all the following):	
☐ searched at least 2 databases (relevant to research question) ☐ provided key word and/or search strategy ☐ justified publication restrictions (e.g. language)	☐ searched the reference lists / bibliographies of included studies ☐ searched trial/study registries ☐ included/consulted content experts in the field ☐ where relevant, searched for grey literature ☐ conducted search within 24 months of completion of the review	☐ Yes ☐ Partial Yes ☐ No

5. Did the review authors perform study selection in duplicate?

For Yes, either ONE of the following:	
☐ at least two reviewers independently agreed on selection of eligible studies and achieved consensus on which studies to include ☐ OR two reviewers selected a sample of eligible studies and achieved good agreement (at least 80 percent), with the remainder selected by one reviewer.	☐ Yes ☐ No

AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both

6. Did the review authors perform data extraction in duplicate?

For Yes, either ONE of the following:
- ☐ at least two reviewers achieved consensus on which data to extract from included studies
- ☐ OR two reviewers extracted data from a sample of eligible studies and achieved good agreement (at least 80 percent), with the remainder extracted by one reviewer.

☐ Yes ☐ No

7. Did the review authors provide a list of excluded studies and justify the exclusions?

For Partial Yes:
- ☐ provided a list of all potentially relevant studies that were read in full-text form but excluded from the review

For Yes, must also have:
- ☐ Justified the exclusion from the review of each potentially relevant study

☐ Yes ☐ Partial Yes ☐ No

8. Did the review authors describe the included studies in adequate detail?

For Partial Yes (ALL the following):
- ☐ described populations
- ☐ described interventions
- ☐ described comparators
- ☐ described outcomes
- ☐ described research designs

For Yes, should also have ALL the following:
- ☐ described population in detail
- ☐ described intervention in detail (including doses where relevant)
- ☐ described comparator in detail (including doses where relevant)
- ☐ described study's setting
- ☐ timeframe for follow-up

☐ Yes ☐ Partial Yes ☐ No

9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?

RCTs

For Partial Yes, must have assessed RoB from
- ☐ unconcealed allocation, *and*
- ☐ lack of blinding of patients and assessors when assessing outcomes (unnecessary for objective outcomes such as all-cause mortality)

For Yes, must also have assessed RoB from:
- ☐ allocation sequence that was not truly random, *and*
- ☐ selection of the reported result from among multiple measurements or analyses of a specified outcome

☐ Yes ☐ Partial Yes ☐ No ☐ Includes only NRSI

NRSI

For Partial Yes, must have assessed RoB:
- ☐ from confounding, *and*
- ☐ from selection bias

For Yes, must also have assessed RoB:
- ☐ methods used to ascertain exposures and outcomes, *and*
- ☐ selection of the reported result from among multiple measurements or analyses of a specified outcome

☐ Yes ☐ Partial Yes ☐ No ☐ Includes only RCTs

10. Did the review authors report on the sources of funding for the studies included in the review?

For Yes
- ☐ Must have reported on the sources of funding for individual studies included in the review. Note: Reporting that the reviewers looked for this information but it was not reported by study authors also qualifies

☐ Yes ☐ No

AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both

11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?

RCTs

For Yes:

- ☐ The authors justified combining the data in a meta-analysis
  - ☐ AND they used an appropriate weighted technique to combine study results and adjusted for heterogeneity if present.
  - ☐ AND investigated the causes of any heterogeneity

☐ Yes
☐ No
☐ No meta-analysis conducted

For NRSI

For Yes:

- ☐ The authors justified combining the data in a meta-analysis
  - ☐ AND they used an appropriate weighted technique to combine study results, adjusting for heterogeneity if present
  - ☐ AND they statistically combined effect estimates from NRSI that were adjusted for confounding, rather than combining raw data, or justified combining raw data when adjusted effect estimates were not available
  - ☐ AND they reported separate summary estimates for RCTs and NRSI separately when both were included in the review

☐ Yes
☐ No
☐ No meta-analysis conducted

12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?

For Yes:

- ☐ included only low risk of bias RCTs
- ☐ OR, if the pooled estimate was based on RCTs and/or NRSI at variable RoB, the authors performed analyses to investigate possible impact of RoB on summary estimates of effect.

☐ Yes
☐ No
☐ No meta-analysis conducted

13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?

For Yes:

- ☐ included only low risk of bias RCTs
- ☐ OR, if RCTs with moderate or high RoB, or NRSI were included the review provided a discussion of the likely impact of RoB on the results

☐ Yes
☐ No

14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?

For Yes:

- ☐ There was no significant heterogeneity in the results
- ☐ OR if heterogeneity was present the authors performed an investigation of sources of any heterogeneity in the results and discussed the impact of this on the results of the review

☐ Yes
☐ No

15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?

For Yes:

- ☐ performed graphical or statistical tests for publication bias and discussed the likelihood and magnitude of impact of publication bias

☐ Yes
☐ No
☐ No meta-analysis conducted

AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both

16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

For Yes:

- ☐ The authors reported no competing interests OR
- ☐ The authors described their funding sources and how they managed potential conflicts of interest

☐ Yes
☐ No

To cite this tool: Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, Moher D, Tugwell P, Welch V, Kristjansson E, Henry DA. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. BMJ. 2017 Sep 21;358:j4008.

6.9 Addendum I: McMaster Critical Review Form

Critical Review Form – Quantitative Studies
©Law, M., Stewart, D., Pollock, N., Letts, L. Bosch, J., & Westmorland, M.
McMaster University
- Adapted Word Version Used with Permission –

The EB Group would like to thank Dr. Craig Scanlan, University of Medicine and Dentistry of NJ, for providing this Word version of the quantitative review form.

Instructions: Use tab or arrow keys to move between fields, mouse or spacebar to check/uncheck boxes.

CITATION	Provide the full citation for this article in APA format:
STUDY PURPOSE Was the purpose stated clearly? ☐ Yes ☐ No	Outline the purpose of the study. How does the study apply to your research question?
LITERATURE Was relevant background literature reviewed? ☐ Yes ☐ No	Describe the justification of the need for this study:
DESIGN ☐ Randomized (RCT) ☐ cohort ☐ single case design ☐ before and after ☐ case-control ☐ cross-sectional ☐ case study	Describe the study design. Was the design appropriate for the study question? (e.g., for knowledge level about this issue, outcomes, ethical issues, etc.): Specify any biases that may have been operating and the direction of their influence on the results:
SAMPLE N = Was the sample described in detail? ☐ Yes ☐ No Was sample size justified? ☐ Yes ☐ No ☐ N/A	Sampling (who; characteristics; how many; how was sampling done?) If more than one group, was there similarity between the groups?: Describe ethics procedures. Was informed consent obtained?:

1

<table>
<tr><td rowspan="2">OUTCOMES

Were the outcome measures reliable?
☐ Yes
☐ No
☐ Not addressed

Were the outcome measures valid?
☐ Yes
☐ No
☐ Not addressed</td><td colspan="2">Specify the frequency of outcome measurement (i.e., pre, post, follow-up):</td></tr>
<tr><td>Outcome areas:</td><td>List measures used.:</td></tr>
<tr><td>INTERVENTION

Intervention was described in detail?
☐ Yes
☐ No
☐ Not addressed

Contamination was avoided?
☐ Yes
☐ No
☐ Not addressed
☐ N/A

Cointervention was avoided?
☐ Yes
☐ No
☐ Not addressed
☐ N/A</td><td colspan="2">Provide a short description of the intervention (focus, who delivered it, how often, setting). Could the intervention be replicated in practice?</td></tr>
<tr><td>RESULTS

Results were reported in terms of statistical significance?
☐ Yes
☐ No
☐ N/A
☐ Not addressed

Were the analysis method(s) appropriate?
☐ Yes
☐ No
☐ Not addressed</td><td colspan="2">What were the results? Were they statistically significant (i.e., $p < 0.05$)? If not statistically significant, was study big enough to show an important difference if it should occur? If there were multiple outcomes, was that taken into account for the statistical analysis?</td></tr>
</table>

Clinical importance was reported? ☐ Yes ☐ No ☐ Not addressed	What was the clinical importance of the results? Were differences between groups clinically meaningful? (if applicable)
Drop-outs were reported? ☐ Yes ☐ No	Did any participants drop out from the study? Why? (Were reasons given and were drop-outs handled appropriately?)
CONCLUSIONS AND IMPLICATIONS Conclusions were appropriate given study methods and results ☐ Yes ☐ No	What did the study conclude? What are the implications of these results for practice? What were the main limitations or biases in the study?

6.10 Addendum J: Key Words Used

2. Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges, Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range
3. Maximal Inspiratory Pressure OR Inspiratory Pressure, Maximal OR Inspiratory Pressures, Maximal OR Maximal Inspiratory Pressures OR Pressure, Maximal Inspiratory OR Pressures, Maximal Inspiratory OR Maximum Inspiratory Pressure OR Inspiratory Pressure, Maximum OR Inspiratory Pressures, Maximum OR Maximum Inspiratory Pressures OR Pressure, Maximum Inspiratory OR Pressures, Maximum Inspiratory OR MIP
4. Hand Strengths OR Strength, Hand OR Strengths, Hand OR Grip OR Grips OR Grasp OR Grasps
5. JAMAR dynamometer
6. Deltoid strength OR shoulder abduction strength
7. quadriceps strength OR knee extension strength
8. 6MWT OR six-minute walk test OR 6-minute walk test OR functional exercise capacity
9. Physical therapy OR Physiotherapy
10. Healthy OR healthy subjects

6.11 Addendum K: Search Strategy and Databases searched (Primary Search)

Muscle strength Assessment Inception 28 January 2020			
Database	Search strategy	Limits	Hits
1. Science Direct	Reference value AND muscle strength AND normative	• 2009-2020 • Review articles • Publication title: Archives of Physical medicine and Rehabilitation	**17**
2. EBSCOHOST-MEDLINE	Reference value AND muscle strength AND normative	• Review articles • English	**4**
3. EBSCOHOST-CINAHL	Reference value AND muscle strength OR shoulder abduction strength OR knee extension strength AND normative	• 2009-2019 • English • All Adult • Major Heading: reference values, muscle strength	**21**
4. Web of Science	TI = (Reference value) AND (muscle strength OR shoulder abduction strength OR knee extension strength) AND (normative)	• Review articles • English Language • 2009-2019	**2**
5. PubMed	Reference value AND knee extension strength OR shoulder abduction strength AND normative	• Review articles • Meta-analysis • Humans	**24**
6. Scopus	Reference value AND muscle strength OR shoulder abduction strength OR knee extension strength AND normative	• 2009-2019 • Review articles • Keyword: Medicine; Health Professions; Nursing	**7**
			75

Grip Strength Inception 28 January 2020			
Database	Search strategy	Limits	Hits
1. Science Direct	Reference value AND Grip strength AND Hand strength AND Normative	• Review articles • 2009-2020	**70**
2. EBSCOHOST-MEDLINE	Reference value AND (grip strength or hand strength) AND normative	• Review articles • English Language • Human • All Adult	**2**
3. EBSCOHOST-CINAHL	reference values AND grip strength OR hand strength	• Review articles • English Language	**1**
4. Web of Science	TI= (Reference value OR Normative reference value) AND (Grip strength OR Hand strength)	• Review articles • English Language • 2009-2019	**22**
5. Pubmed	((((Reference Values) AND Grip strength) OR Hand strength) OR Grasp) AND Normative	• Review articles • 2009-2020	**8**
6. Scopus	Reference value AND Grip strength OR Hand Strength AND Normative	• Review articles • 2009-2020 • Keywords: Medicine; Health Professions; Nursing, Human, English language	**60**
			163

Maximal Inspiratory Pressure Inception 28 January 2020			
Database	Search strategy	Limits	Hits
1. Science Direct	Normative AND Reference Value AND Maximal Inspiratory Pressure OR Inspiratory Pressure AND healthy subjects AND physiotherapy	• Review articles • 2009-2020 • Publication titles: Physiotherapy;Archives of physical medicine and rehabilitation;Respiratory medicine;Clinics in chest medicine; Respiratory Physiology and Neurobiology	**23**
2. EBSCOHOST-MEDLINE	Reference Value AND Maximal inspiratory pressure OR Inspiratory Pressure, Maximal OR Inspiratory Pressures AND normative	• Review articles • 2009-2020 • English Language • All Adult 19+ years	**8**
3. EBSCOHOST-CINAHL	Reference Value AND Maximal inspiratory pressure OR Inspiratory Pressure, Maximal OR Inspiratory Pressures AND normative	• Review articles • English Language • Human • All Adult ages	**4**
4. Web of Science	TI= (Reference Value) *AND* (Maximal inspiratory pressure) *OR* TI=(Inspiratory Pressure, Maximal) *OR* TI= (Inspiratory Pressures) *AND* TI=(normative)	• Review articles • 2009-2019	**1**
5. Pubmed	((((Reference value) AND Maximal inspiratory pressure) OR Inspiratory pressure) OR MIP) AND Normative	• Review articles • 2009-2020	**3**
6. Scopus	Reference Value AND Maximal inspiratory pressure OR Inspiratory Pressure, Maximal OR Inspiratory Pressures AND normative	• Review articles • Keyword=Adult • English • 2009-2019	**3**
			42

Exercise capacity **Inception 28 January 2020**			
Database	Search strategy	Limits	Hits
1. Science Direct	Reference Value AND six minute walk test OR 6mwt OR exercise tolerance AND normative	• 2009-2020 • Review articles • Archives of physical medicine and rehabilitation; Physiotherapy	**69**
2. EBSCOHOST-MEDLINE	Reference Value AND six minute walk test OR 6mwt OR exercise tolerance AND normative	• Review articles • English Language • All Adult	**20**
3. EBSCOHOST-CINAHL	Reference Value AND six minute walk test OR 6mwt OR exercise tolerance AND normative	• Review articles • English Language • All Adult 19+ • Human	**7**
4. Web of Science	ti= (Reference value) AND (six minute walk test or walking tests)	• Review articles	**3**
5. Pubmed	((((Reference value) AND rehabilitation) OR walking test) OR six minute walk test) AND normative	• Review articles • Meta- analysis • Humans • English	**35**
6. Scopus	Reference Value AND six minute walk test	• Review articles	**10**
			144

6.12 Addendum L: Search Strategy and Databases searched (Secondary Search)

MEDLINE – EBSCOHOST Accessed: 1 August 2019 Limiters: • Date of Publication: 2009-2019 • Search modes: Boolean/Phrase • Review	
Search Terms	**Initial Hits**
(Reference Value OR Value, Reference OR Values Reference OR Normal Range OR Normal Ranges OR Range, Normal OR Ranges, Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (healthy OR healthy subjects) AND (Maximal Inspiratory Pressure OR Inspiratory Pressure, Maximal OR Inspiratory Pressures, Maximal OR Maximal Inspiratory Pressures OR Pressure, Maximal Inspiratory OR Pressures, Maximal Inspiratory OR Maximum Inspiratory Pressure OR Inspiratory Pressure, Maximum OR Inspiratory Pressures, Maximum OR Maximum Inspiratory Pressures OR Pressure, Maximum Inspiratory OR Pressures, Maximum Inspiratory OR MIP)	2
(Reference Value OR Value, Reference OR Values Reference OR Normal Range OR Normal Ranges OR Range, Normal OR Ranges, Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (Hand Strengths OR Strength,Hand OR Strengths,Hand OR Grip OR Grips OR Grasp OR Grasps) AND (systematic review OR meta-analysis)	8
(Reference Value OR Value, Reference OR Values Reference OR Normal Range OR Normal Ranges OR Range, Normal OR Ranges, Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (muscle strength) AND (systematic review OR meta-analysis)	13

(Reference Value OR Value, Reference OR Values Reference OR Normal Range OR Normal Ranges OR Range, Normal OR Ranges, Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (6MWT OR six minute walk test OR 6 minute walk test OR functional exercise capacity) AND (systematic review OR meta-analysis)	4
Total	**27**

Science Direct Accessed: 1 August 2019 Limiters: • Years: 2009 – 2019	
Search Terms	**Initial Hits**
(Reference values OR normative reference values) AND (Maximal inspiratory strength OR Maximal inspiratory pressure OR MIP) AND (grip strength) AND (muscle strength) AND (six minute walk test OR 6MWT) AND (healthy OR healthy subjects)	10
Total	**10**

Pubmed

Accessed: 1 August 2019

Limiters:

- Review
- Published in the last 10 years
- Human

#	Search Terms	Initial Hits
#3	Search(#1 AND #2)	20
#2	Search (((((((Maximal Inspiratory Pressure[Title/Abstract] OR Inspiratory Pressure, Maximal[Title/Abstract] OR Inspiratory Pressures, Maximal[Title/Abstract] OR Maximal Inspiratory Pressures[Title/Abstract] OR Pressure, Maximal Inspiratory[Title/Abstract] OR Pressures, Maximal Inspiratory[Title/Abstract] OR Maximum Inspiratory Pressure[Title/Abstract] OR Inspiratory Pressure, Maximum[Title/Abstract] OR Inspiratory Pressures, Maximum[Title/Abstract] OR Maximum Inspiratory Pressures[Title/Abstract] OR Pressure, Maximum Inspiratory[Title/Abstract] OR Pressures, Maximum Inspiratory[Title/Abstract] OR MIP[Title/Abstract])) OR (Maximal Inspiratory Pressure OR Inspiratory Pressure, Maximal OR Inspiratory Pressures, Maximal OR Maximal Inspiratory Pressures OR Pressure, Maximal Inspiratory OR Pressures, Maximal Inspiratory OR Maximum Inspiratory Pressure OR Inspiratory Pressure, Maximum OR Inspiratory Pressures, Maximum OR Maximum Inspiratory Pressures OR Pressure, Maximum Inspiratory OR Pressures, Maximum Inspiratory OR MIP[MeSH Terms]) AND ((Hand Strengths[Title/Abstract] OR Strength, Hand[Title/Abstract] OR Strengths, Hand[Title/Abstract] OR Grip[Title/Abstract] OR Grips[Title/Abstract] OR Grasp[Title/Abstract] OR	400

	Grasps[Title/Abstract])) OR (Hand Strengths OR Strength, Hand OR Strengths, Hand OR Grip OR Grips OR Grasp OR Grasps[MeSH Terms]) AND muscle strength [Title/Abstract] OR dynamometer,muscle strength[MeSH Terms]) AND ((6MWT[Title/Abstract] OR six minute walk test[Title/Abstract] OR 6 minute walk test[Title/Abstract] OR functional exercise capacity[Title/Abstract])) OR (6MWT OR six minute walk test OR 6 minute walk test OR functional exercise capacity[MeSH Terms])	
#1	Search ((Reference Value[Title/Abstract] OR Value, Reference[Title/Abstact] OR Values Reference[Title/Abstract] OR Normal Range[Title/Abstract] OR Normal Ranges[Title/Abstract] OR Range, Normal [Title/Abstract] OR Ranges, Normal [Title/Abstract] OR Normal Values [Title/Abstract] OR Normal Value [Title/Abstract] OR Value,Normal [Title/Abstract] OR Values,Normal [Title/Abstract] OR Reference Ranges [Title/Abstract] OR Range,Reference [Title/Abstract] OR Ranges,Reference [Title/Abstract] OR Reference Range [Title/Abstract])) OR (Reference ValuecOR Value, Reference OR Values Reference OR Normal Range OR Normal Ranges OR Range, Normal OR Ranges, Normal OR Normal Values OR Normal Value OR Value,Normal OR Values,Normal OR Reference Ranges OR Range,Reference OR Ranges,Reference OR Reference Range[MeSH Terms])	11947
	Total	**20**

Scopus

Accessed: 1 August 2019

Limiters:

- Subject Area: Medicine, Health Professions and Nursing
- 2009-2019
- Keywords: Human, Humans
- Review

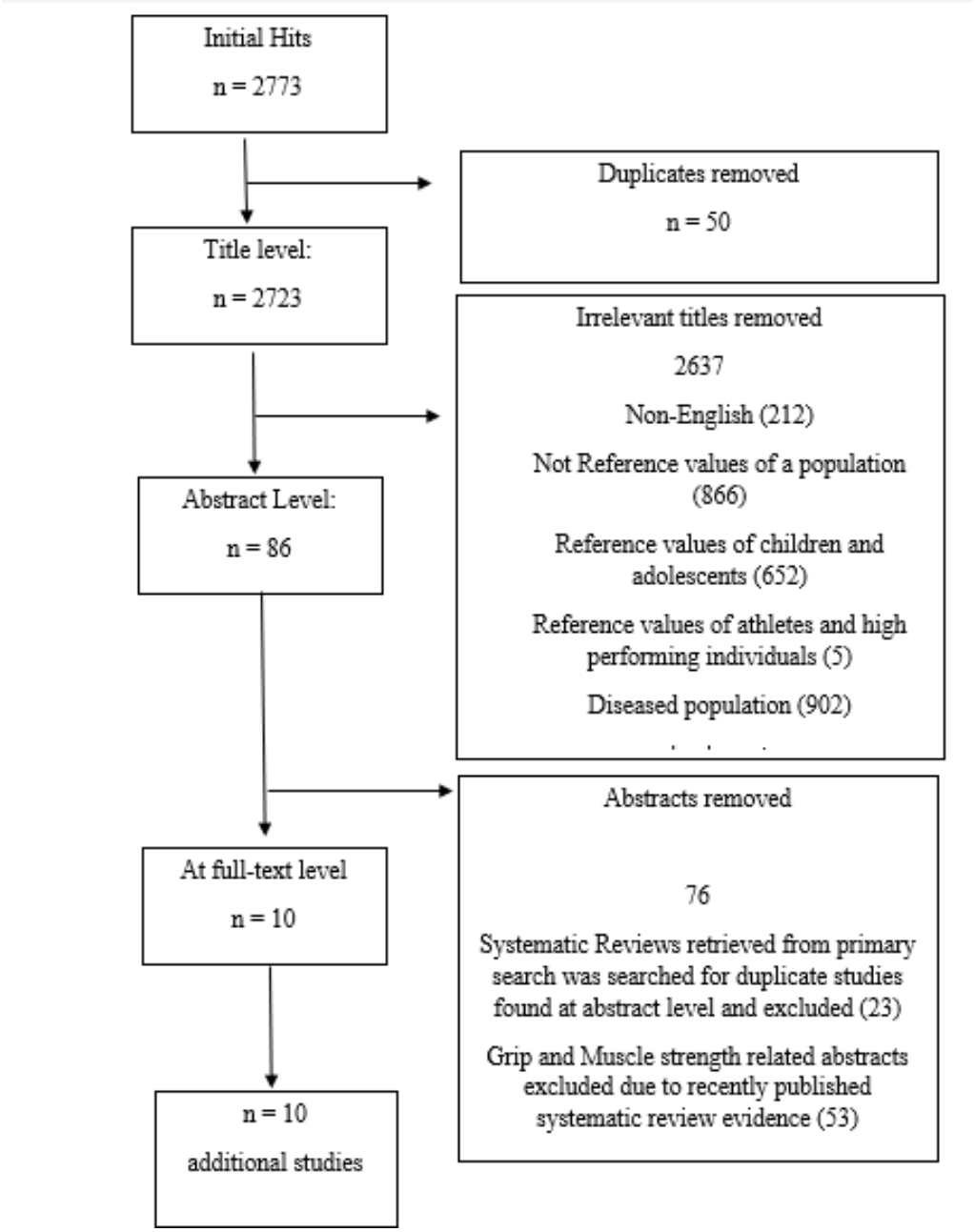
Search Terms	**Initial Hits**
(Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges,Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (Healthy OR Healthy subjects) AND (Maximal Inspiratory Pressure OR Inspiratory Pressure, Maximal OR Inspiratory Pressures, Maximal OR Maximal Inspiratory Pressures OR Pressure, Maximal Inspiratory OR Pressures, Maximal Inspiratory OR Maximum Inspiratory Pressure OR Inspiratory Pressure, Maximum OR Inspiratory Pressures, Maximum OR Maximum Inspiratory Pressures OR Pressure, Maximum Inspiratory OR Pressures, Maximum Inspiratory OR MIP)	4
(Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges,Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (Healthy OR Healthy subjects) AND (Grip OR Grip strength)	30
(Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges,Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (quadriceps strength)	40
(Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges,Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR	10

Range, Reference OR Ranges, Reference OR Reference Range) AND (deltoid strength)	
(Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges,Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (Healthy OR Healthy subjects) AND (6MWT OR six minute walk test OR 6 minute walk test OR functional exercise capacity)	9
Total	**93**

CINAHL - EBSCOHOST Accessed: 1August 2019 Limiters: • Published date: 2009-2019 • Search modes: Boolean/Phrase	
Search Terms	**Initial Hits**
(Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges,Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (Maximal Inspiratory Pressure OR Inspiratory Pressure, Maximal OR Inspiratory Pressures, Maximal OR Maximal Inspiratory Pressures OR Pressure, Maximal Inspiratory OR Pressures, Maximal Inspiratory OR Maximum Inspiratory Pressure OR Inspiratory Pressure, Maximum OR Inspiratory Pressures, Maximum OR Maximum Inspiratory Pressures OR Pressure, Maximum Inspiratory OR Pressures, Maximum Inspiratory OR MIP)	48
(Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges,Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (grip strength or hand strength)	47
(Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges,Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (muscle strength)	64
(Reference Value OR Value, Reference OR Values Reference OR Normal Range Or Normal Ranges OR Range, Normal OR Ranges,Normal OR Normal Values OR Normal Value OR Value, Normal OR Values, Normal OR Reference Ranges OR Range, Reference OR Ranges, Reference OR Reference Range) AND (6MWT OR 6 minute walk test)	35
Total	**194**

Web of Science Accessed: 1 August 2019 Limiters: • Human • TI= Title	
Search Terms	**Initial Hits**
TI=(Reference values OR normal values) AND (Maximal inspiratory pressure OR MIP OR Inspiratory pressure) OR (Reference values OR normal values) AND (hand strength OR grip strength OR grip) OR (Reference values OR normal values) AND (deltoid strength OR shoulder abduction strength) OR (Reference values OR normal values) AND (quadriceps strength OR knee extension strength) OR (Reference values OR normal values) AND (6MWT OR six minute walk test OR 6 minute walk test OR functional exercise capacity) AND (systematic review OR meta-analysis)	9
Total	**9**

6.13 Addendum M: Secondary Search Selection Process Flow Diagram



6.14 Addendum N: Summary of procedure and postioning (Deltoids)

Muscle	Procedure & Positioning	Bohhanon et al.(2011)	Benfica et.al (2018)	Bohhanon et al.(2017) updated
Deltoids	**Procedure**	NR	Two trials performed. Six to seven seconds of contraction with a rest time of one minute in-between. The instrument used is a dynamometer recording a peak force by means of a make test. The unit of measure is Newtons.	NR
	Positioning	NR	Supine – shoulder abducted to 45°, elbow extended. Resistance given proximal to styloid processes and stabilization at elbow.	NR
	Instruments used	Hand-held electronic dynamometer (Chatillon) Hand-held dynamometer (Penny and Giles) Hand-held dynamometer (CIT) Hand-held dynamometer (Ametek digital) Hand-held dynamometer (Spark)	Hand-held electronic dynamometer (Chatillon) Hand-held dynamometer (Penny and Giles) Hand-held dynamometer (CIT) Hand-held dynamometer (Ametek digital) Nicholas Manual Muscle tester (Lafayette instrument) Isobex dynamometer Hand dynamometer (Type HKRM) Hand-held myometer(Penny and Giles) Dynamometer (Modified Cybex) Modified sphygmomanometer hand-grip dynamometer	NR

NR = Not Reported

6.15 Addendum O: Summary of procedure and positioning (Quadriceps)

Muscle	Procedure & Positioning	Bohhanon et al.(2011)	Benfica et.al (2018)	Bohhanon et al.(2017)
Quadriceps	**Procedure**	NR	Two trials performed. Six to seven seconds of contraction with a rest time of one minute in-between. The instrument used is a dynamometer recording a peak force by means of a make test. The unit of measure is Newtons.	NR
	Positioning	NR	Seated – hips and knees flexed at 90° with hands resting on lap. Resistance given proximal to malleoli and stabilization at the shoulders by an assistant.	Seated – knees flexed at 90°. Dynamometer applied to the anterior leg just proximal to the malleoli.
	Instrument used	Nicholas Manual Muscle tester (Lafayette) Hand-held electronic dynamometer (Chatillon) Hand-held dynamometer (Penny and Giles)	Hand-held electronic dynamometer (Chatillon) Hand Held dynamometer (CIT) Hand-held dynamometer (Ametek digital) Fixed Dynamometry Portable electronic dynamometer(Penny and Giles) Modified Sphygmomanometer Strain gauge dynamometer	Digital hand dynamometer

		Hand Held dynamometer (CIT) Hand-held dynamometer (Ametek digital) Hand-held dynamometer (MicroFet)		

NR = Not Reported

6.16 Addendum P: Summary of Procedures followed to assess Maximal Inspiratory Pressure

Systematic Review and Meta-analysis	Procedure	Positioning	Starting volume	Time of MIP	Trials	Criteria for stopping
Pessoa et al.(2014)	NR	NR	RV	Without control Max 1.5s Min of 1s 2s Min f 2s About 1s	Min of 5 Max of 3 Min of 3 Min of 4 3-5 5 Max of 5 Min of 7 NS	Highest value 2 identical readings Highest 2 values within 5% difference Highest 3 values withing 5% difference Highest 2 values within 10% difference Highest value of 3 similar trials Highest value < 10% of 3 trials Highest value varying 5% Highest value <10% of all trials
Additional studies						
Pessoa et al.(2014)	Instructions and demonstration given prior to testing. The participant is encouraged to generate a maximal inspiratory pressure while the tester closes the occlusion orifice with a standard command.	Sitting Legs and trunks supported	RV	1.5s	5 with 1 minute interval inbetween	Three reproducible tests one with varaition less than or eqaul to 10% variation nomore than 20% with pressure of higher value

NR = Not Reported ; RV = Residual Volume