An Instrument to Assess the Fitness of Field Athletes with Physical Disabilities

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part, submitted it to any university for a degree.

ABSTRACT

The purpose of this study was to determine the validity of a series of physical fitness tests for athletes with disabilities competing in sitting throwing events in athletics. All athletes competing in sitting throwing events during the South African National Championships April, 2001, were asked to take part in the research study. A total of 74 athletes in the classes F33, F34, F52, F53, F54, F55, F56, F57 and F58 took part in the research study. All the athletes completed the tests selected for their specific class. Their tests results and their performance in the events at the South African National Championships were correlated to determine the validity of the physical fitness tests.

Results of the study revealed the following:

- ✓ Certain physical fitness components are more important than others for achieving good results in the sitting throwing events.
- ✓ Upper body power is the best predictor of performance in all the events and classes.
- ✓ Technique is as important a factor in good performance as is fitness.
- ✓ South African athletes' technique needs improvement.

It can be concluded from this study that physical fitness, in particular upper body strength and power, plays a major role in performance of athletes with disabilities competing in sitting throwing events. Many of the athletes are currently top performers rely more on their physical fitness than on good technique to achieve success. If these athletes can combine physical fitness with good technique, much better performances will achieved and the world will need to take even more note of South Africa's athletes with disabilities.

OPSOMMING

Die doel van hierdie studie was om die geldigheid, van spesifieke fiksheidstoetse vir atlete met gestremdhede wat deelneem aan sittende velditems in atletiek, te bepaal. Al die atlete wat deelgeneem het aan sittende velditems tydens die Suid-Afrikaanse Atletiek Kampioenskappe vir persone met gestremdhede, is uitgenooi om deel te neem aan die navorsingsstudie. Altesaam 74 atlete van die klasse F33, F34, F52, F53, F54, F55, F56, F57 en F58 het deelgeneem aan die spesifieke fiksheidtoetsprotokol wat vir elke klas opgestel was. 'n Pearson korrelasie is getref tussen die toetsresultate en die prestasie van elke atleet in die verskillende items tydens die Suid-Afrikaanse kampioenskappe, om sodoende die geldigheid van elke fiksheidstoets te bepaal.

Die volgende bevindinge is gemaak:

- ✓ Seker fiksheidskomponente (in sittende velditems) is meer belangrik as ander vir deelnemers met gestremdhede.
- ✓ Prestasie in sittende velditems van al die klassifikasie groepe kan die beste bepaal word deur plofkrag in die boonste ledemate.
- ✓ Korrekte tegniek is net so belangrik vir prestasie as fisieke vermoë.
- ✓ Suid-Afrikaanse atlete se tegniek kan beslis verbeter.

'n Gevolgtrekking kan gemaak word dat krag en plofkrag van die boonste ledemate, van atlete met gestremdhede wat deelneem aan sittende velditems, 'n belangrike fisieke komponent is vir prestasie. Baie atlete wat tans toppresteerders is, presteer nie noodwendig omdat hulle die beste tegniek het nie, maar weens hulle fisieke vermoëns. Indien daaarin geslaag word om die tegniek en fisieke vermoëns van sittende veldatlete te verbeter, sal nog meer Suid-Afrikaanse atlete internasionaal presteer.

To my MOM

And

The South African Paralympic Team 2000

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Chapter One

Setting the Problem

Sport has value in anyone's life, but it is even more important in the life of a person with a disability. Sport's rehabilitative influence and the fact that it integrates the person into society drew many medical doctors to explore the potential of sport for rehabilitative purposes for individuals with disabilities. Sport for physically disabled persons was introduced after World War II, with its large number of injured servicemen, -women and civilians. In researching new methods to minimize the consequences of their immobility, it provided a new and great possibility for reviving the idea of sport as a way of treatment and rehabilitation. Nowadays, people with disabilities participate in high performance as well as in competitive and recreational sport (http://www.paralympic.org).

Competitive sport for individuals with disabilities was elevated to international prominence in 1976 when most of the disability groups were included in the Paralympic games, created as a parallel event to the Olympics. However, a general acknowledgement by the world that individuals with disabilities can be athletes in their own right is still a dream waiting to be realised. This lack of recognition has contributed to a situation where relatively little scientific research about competitive sport for individuals with disabilities has been published, and a lack of scientific support for coaching and training methods has been the result. Many modern athletes give credit to scientific support when achieving results. But lack of scientific support for athletes with disabilities regarding testing, feedback, normative data and sport-specific training according to each individual's disability, is a major source of concern.

The Canadian Journal for Applied Physiology (1998) published an entire journal on the subject of physical assessment and writing training programmes for individuals with disabilities. In the first chapter, they highlighted the inability of fitness specialists to provide people with disabilities with fitness assessment and exercise programmes. Inaccessible facilities, training personnel not knowledgeable about disabilities and the general exclusion of individuals with disabilities from physical activities, were all identified as factors contributing to this situation. A lack of understanding of the importance of physical fitness to individuals with disabilities was also seen as a factor.

Physical fitness traditionally has been defined as:

> ...the ability to carry out tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuit and to meet unusual situations and unforeseen emergencies (Winnick, 1990:301).

Winnick (1990) stated that the definition of physical fitness has been extended and is now conceptualised as a "multifaceted continuum extending from birth" (p. 301). Certain tests are used to measure physical fitness. These tests fall into two different categories:

- Tests that measure the components of health-related fitness
- Tests that measure the components of athletic or performance-related fitness.

Some components of health-related fitness also can be considered to be performance-related components for certain sports.

Differences in the interpretation of the term physical fitness depend upon whether fitness is desired for health or for athletic performance. Where successful, rewarding and enjoyable participation in sport is desired, higher levels of physical fitness are necessary (Maud & Foster, 1995). According to Watson (1995) physical performance is a function of all of the physical and mental characteristics of the individual. Some of these characteristics are genetic and others are acquired. An athlete has little or no influence over his/her genetic factors, e.g. age, gender, somatotype, height and the distribution of motor unit types. However, it is possible to have a substantial impact on the acquired factors, such as strength, flexibility and endurance. It is important to test these acquired factors during a physical assessment, because they can be improved by the athlete.

Compton et al. (1989) said that the term "fitness" implies that a specified level of function has been achieved, while the terms "exercise" and "physical activity" imply only participation in an activity that is physical in nature. Accordingly to Compton, this distinction is very important for all individuals with disabilities. It means that participation in regular low intensity physical activities can produce benefits, but those benefits will not necessarily include physical fitness. Physical fitness is achieved only if they can demonstrate a specified level of function for each of the fitness components. The physical components of fitness were defined as muscular strength and endurance, cardiovascular fitness, and body composition.

It is not only a lack of understanding of fitness assessment and programming that is an obstacle to physical fitness for athletes with disabilities. Sandiago et al. (1993) stated that there are numerous other obstacles faced by individuals with physical disabilities. The obstacles include limitations because of their particular disability or obstacles in the environment. Environmental obstacles can be overcome to some extent with some general changes to the environment, but limitations associated with the disability are much more individualised. Disability has been defined by Compton, Eisenman and Henderson (1989) as:

> ...a chronic condition due to physiological, anatomical, mental or emotional impairment resulting from disease or illness, inherited or congenital defect, trauma or other insult to the body or mind (p. 151).

According to them the most obvious impact a disability can have on an individual is a limitation of the ability to engage in physical activity or exercise. Inactivity leads to deconditioning and produces a lower capacity to perform the activities required for daily living.

Purpose of the Study

The purpose of the study was to help overcome the fitness assessment problems associated with providing sport science support to participants in disability sport. The development of a testing instrument for athletes with physical disabilities competing in the sitting throwing events was adopted as the specific focus. This study represents a starting point for not only the development of sport-specific fitness assessment protocols, but also disability-specific protocols. The value of specific protocols is that they can produce the information that will lead to the design of optimal fitness programmes for improving sport performance.

Significance of the Study

The desire to help athletes becoming the best they can by helping them improve their physical fitness was a major motivational factor for this study. Currently, there is information about health-related fitness for individuals with disabilities, but information about fitness for sport-related performance is difficult to find. When working with individuals with disabilities, one is too easily satisfied with what these athletes already have achieved by overcoming so many obstacles. One can forget to focus on what their real potential may be. By designing a way to assess current levels of physical fitness with tests relevant to the sport and the disability, the real potential of these athletes may be realised and the world may stand in awe. If one only takes note of all the physical fitness assessments been done on able-bodied athletes, one cannot but wonder what will happen if athletes with disabilities get this type of scientific support.

The challenges faced by athletes with disabilities are significant. Scientific support regarding physical assessments, biomechanical adaptations, ergonomics and knowledge for coaches about how to adapt the sport for individuals with disabilities, could make a major contribution to disability sport. Martin et al. (1996:113-115) noted that sport for persons with disabilities can be seen as an effective tool for getting able-bodied people to see the "abilities" of individuals with disabilities. He states that a lack of awareness, indifferent and negative attitudes towards sport opportunities for people with disabilities result in limited research, funding and recruitment of coaches and athletes. There is also a perception that individuals with disabilities aren't real athletes. Athletes with disabilities who are properly trained and who have achieved high levels of fitness and sport performance can correct these negative perceptions. The testing protocols developed within this study should assist in this effort.

Research Questions

The following research questions guided this study:

1. What are the test items in a valid physical fitness test battery for athletes with physical disabilities who compete in the sitting shot put event?

2. What are the test items in a valid physical fitness test battery for athletes with physical disabilities who compete in the sitting javelin event?

3. What are the test items in a valid physical fitness test battery for athletes with physical disabilities who compete in the sitting discus event?

4. Are performances on any of the test items particularly good predictors of actual performance during competition in any of the sitting throwing events?

Methodology

The content and methods use to construct this testing instrument were done with only one thing in mind: the enhancement of the athletes' performances. In order to improve knowledge regarding the concept of this study, a literature search was completed on physical disabilities, fitness and disabilities, current trends in fitness and able-body athletes. Tests were selected according to the sport-specific demands of throwing the discus, javelin and putting the shot, and the functional capabilities related to the classification of athletes who throw from the sitting position. A fitness assessment protocol was administered to athletes at the South African Championships for Physical Disabled 2001.

This research was organised as a descriptive study in which 74 athletes who competed in the shot put, javelin, and/or discuss volunteered to complete a carefully designed, physical fitness test batteries. Their scores on the various test items were then correlated to their actual performance in competition during the 2001 South African National Championships for the Physically Disabled. In every case, their performances of the items in the fitness batteries were within three days of their performance in competition. Correlation coefficients were then calculated in order to identify those fitness test items that achieved a positive correlation with actual throwing performance. Because of the larger number of athletes competing in the F55-F58 shot put and discus, it was possible to complete a multiple regression analysis of these scores to determine if any of the test items are particularly good predictors of performance in actual competition in the shot put or discus. The result of this comparison was the identification of which specific tests measures a fitness component that appears to be essential to throwing from a seated position. Refinements in the test protocols were made as a result of this comparison.

Limitations

The following limitations may have had an impact on the test results:

1. The testing was completed during the National Championship, which could have produced lower performance on the fitness tests due either to athletes "saving themselves for the competition" or simply having their attention focused on their competition performance rather than the testing.

2. Many of the athletes who participated had had little experience with fitness testing and this may have influenced their results.

3. There were limited numbers of athletes in the various classes, which led to a "combining of classes" for data analysis. Data from the F33 and F34 athletes (cerebral palsy) were processed as a single group. Data from the F52, F53, and F54 athletes were processed as a group and data from the F55, F56, F57, and F58 athletes were processed as a group (all in the F50 series are spinal cord injuries, les autres, etc.).

4. It was not possible to re-test any of the athletes who took the fitness tests, which meant that traditional test-re-test reliability could not be calculated.

Definitions

Physical fitness

Physical fitness is "a state in which an individual possess qualities of strength, power, agility, flexibility, endurance, balance, speed and general coordination to the extent that he/she is able to meet his everyday needs" (AAHPERD, 1980:19). Physical fitness can refer to the health status of the individual, or to the physical performance capabilities, including athletic ability, of the individual (Winnick and Short, 1985).

Disabilities and sport

Sherrill (1999) defined disabilities in the sporting context as "limitations in physical, mental, or sensory functional ability and activity that prevent or compromise equitable participation in able-bodied sport" (p.206).

The World Health Organization defines impairment as "any loss or abnormality of psychological, physiological or anatomical structure or function." The National Collegiate Athletic Association defines impaired student-athletes as "those who are confined to a wheelchair; those who are deaf, blind, or missing a limb; those who have only one of a paired set of organs; or those who may have behavioural, emotional or psychological disorders that substantially limit a major life activity" (Nichols, 1996:191).

Disability sport

Disability sport is defined by DePauw (1999:50) as sport that has been designed for or specifically practiced by athletes with disabilities. Sherrill (1999) defined excellence in disability sport as synonymous with Paralympics. "An athlete who falls into this category meets the following criteria: The athlete demonstrate an intense desire to excel, to perform at standards approaching personal limits and to compete near or above the highest level of excellence for a particular event within his/her sport classification" (p.206-207).

Summary

According to Liow and Hopkins (1996) athletic performance can be enhanced by modification of physical training, among other factors. Because athletes with disabilities who compete at the Paralympic level train and compete as seriously as their able-bodied peers do (Hamel, 1992), the sport science support for these athletes must be just as refined and specific. This study was designed to produce a valid test of physical fitness that could be used by athletes in the sitting throwing events to help them monitor progress in their physical fitness training, identify weaknesses in their current levels of fitness, and set goals for improvement of their performance through targeted improvement of selected components of physical fitness.

Chapter Two

Review of Literature

Although recreational sport for individuals with disabilities can be traced back to the early 1900's, and competitive sport was taken to the international level with the first Paralympic Games in 1976, sport science research about the participation of persons with disabilities has been much slower to develop. As recently as 1990, there was no data available to provide an account of either the fitness status of persons with disabilities or their response to vigorous, competitive physical activity (Shephard, 1990). Efforts by researchers since that time have produced important information so that it is now possible to assess the fitness status of individuals with disabilities and make recommendations about how they can improve. The following chapter includes a review of current research on the fitness of persons with physical disabilities. This research is focused specifically on identifying valid fitness tests for athletes with physical disabilities who participate in the sitting throwing events (javelin, discuss and shot put), a section is also provided on the movement and fitness requirements of these events.

Physical Disabilities and Fitness

Athletes with a variety of different physical disabilities may be eligible to participate in the sitting throwing events. The impact of each athlete's impairment must be severe enough so that the athlete is unable to compete from a standing position. In other words, he/she must throw from a seated position, e.g. from a wheelchair or a throwing frame. Athletes with different disabilities may be grouped together in the same class for competition, based upon their functional capabilities. However, it is still important to look at the nature of their particular disability in relation to their physical fitness if appropriate tests and methods for improving their fitness are to be identified.

Amputations

An amputation is the absence of one or more limb or appendage. It can be congenital or acquired. Congenital causes result from the failure of a limb/appendage to develop normally in utero, so that part of the limb/appendage is absent at birth. An acquired amputation occurs when a limb/appendage is removed during an accident or surgery (Miller, 1995; Steadward, 1998).

Types of amputations

Acquired amputations can affect any parts of the body, however, there are two subtypes of congenital amputations:

- Dysmelia: the absence of the arms or legs.
- Phocomelia: the absence of the middle segment of a limb, with intact proximal and distal portions, for example the hands are attached to the shoulders and the feet to the hips (Winnick, 1990; Steadward, 1998).

Factors influencing fitness testing and exercise prescription for persons with amputations

There are two factors to consider when identifying appropriate tests and designing exercise programmes for persons with amputations.

1. **Functional loss:** The site and level of amputation will influence the type of exercise and intensity that the athlete can sustain (Steadward, 1998).
2. **Prosthesis:** The type of prosthesis will influence what actions an individual can or cannot perform. A prosthesis cannot replace a lost limb with respect to sensation, force generation, mobility and certain fine motor activities (Steadward, 1998). The performance characteristics of the prosthesis must be analyzed and kept in mind when designing a test or a fitness programme. A prosthesis also may traumatize the remaining portion of the limb (the stump) during vigorous physical activity. The stump must be examined regularly for bruises, skin

irritation and shaving (Winnick, 1990) and adjustments in testing or exercise routines might have to be made to avoid stump injury.

Spinal cord injuries

The spinal cord is comprised of nervous tissue extending from the brain to the lower back. It provides a pathway for neural impulses to and from the brain to the nerves and muscles of the body. The spinal cord is protected by the vertebral column that consists of thirty-three vertebrae (Horvat, 1990). The portion of the cord that passes through each of the vertebrae takes on the label of the level and number of those vertebrae, e.g. the segment passing through thoracic vertebrae #4 is labelled spinal segment T4. Spinal cord injuries involve trauma to segments of the spinal cord that results in altered motor, sensory and/or autonomic nerve function (Steadward, 1998). The amount of paralysis will result from the level and extent of the damage.

Types of spinal cord injury

The higher the level of spinal cord damage (lesions) the more restrictions on movement (Horvat, 1990). Injury to cervical (neck) segments (C1 –C8) or the highest thoracic (chest) segment (T1) results in **quadriplegia or tetraplegia**. An individual with quadriplegia/tetraplegia experiences impairment of the arms, trunk, legs and pelvic organs (ACSM, 1997).

Injury to thoracic (chest) segments T2-T12 results in **paraplegia**. An individual with paraplegia experiences impairment to the trunk, legs and/or pelvic organs. Injury to lumbar or sacral segments (L1-5, S1-4) result in impairment of only the legs or pelvic organs, or both (ACSM, 1997).

Factors influencing fitness testing and exercise prescription for persons with spinal cord injuries

There are nine factors to consider when identifying appropriate tests and designing exercise programmes for persons with spinal cord injuries.

1. **Heart rate:** Maximum heart rates are significantly lower than normal for individuals with lesions above T6 who have sustained damage to the autonomic nervous system. For example, their heart rate may reach only 120 beats per minute during arm ergometry (Steadward, 1998).

2. **Impaired Circulation:** Vasoconstrictor function is lost below the level of a spinal cord lesion. This absence of vasoconstriction causes blood pooling in the lower limbs. Blood pooling results in less venous return, which leads to a reduction in the stroke volume of the heart. Decreased stroke volume combines with decreased heart rate to produce lower peak cardiac output. Although this factor may not impact sub maximal exercise, it is a significant limiting factor on intensity and duration of maximal exercise (Steadward, 1998).

3. **Thermoregulation:** Impairment in thermoregulatory response is experienced below the level of the spinal cord lesion. Lack of sympathetic control mechanisms and vasomotor responses result in increased heat loss below the lesion level, including an inability to "sweat" (Winnick, 1990; Steadward, 1998).

4. **Hypotension:** Due to a lack of vasculature and muscular tone in the lower extremities, blood pressure decreases and blood pooling occurs in the lower extremities. This leads to a decreased blood flow to the brain and heart, which results in low blood pressure (Steadward, 1998). If an individual experiences a blood pressure level less than 80/50, they should wear elastic support stockings and an abdominal binder to elevate resting blood pressure. No vigorous exercise is recommended within three hours of eating a large meal (ACSM, 1997).

5. **Autonomic Dysreflexia/Hyperreflexia:** This is commonly found in people with lesions above T6. This condition is stimulated by a noxious stimulus below the injury level, such as a distended bladder or bowel, or a skin infection (ACSM, 1997). "Symptoms are increased blood pressure, headache, extensive sweating

above level of lesion, nausea, gooseflesh and flushed skin. This response can results in convulsions, cerebral haemorrhage and death" (Steadward, 1998:133).

6. **Spasticity:** "Inhibitory impulses from the brain and decreased excitability of the spinal cord below the lesion level result in spasticity" (Steadward, 1998:133).

7. **Range of Motion:** A spinal cord injury may result in a functional change that alters/diminishes the range of motion at one or more joints (Steadward, 1998).

8. **Skin Breakdown:** Pressure sores and skin problems on certain parts of the body can be the result of prolonged pressure, friction, heat, and moisture. Nutritional deficit, chemical imbalances, renal and cardiovascular complications may also contribute to the forming of pressure sores and skin breakdowns (ACSM, 1997); Steadward, 1998).

9. **Loss of sensation:** Because persons with spinal cord injuries have lost or impaired sensation below the level of lesion, they are not always aware of what is happening to their bodies. Heat, sun, excessive pressure and other environmental hazards can injure a person with a spinal cord injury before he/she is aware of what is happening (Steadward, 1998).

Poliomyelitis

Poliomyelitis is a neuromuscular condition caused by a virus that enters the body through the alimentary canal (Miller, 1995). It attacks the brain and ventral horn of the spinal cord. Degeneration of the motor nerves causes anterior horn cells to die. The muscle fibres associated with these dead neurons lose their capacity to innervate, thus causing muscle weakness. Thirty to forty years after an individual's first attack by the virus, a syndrome call post-polio syndrome can develop. It is characterized by fatigue and weakness, as well as joint and muscle pain (Steadward, 1998).

Types of poliomyelitis

There are three general types of poliomyelitis.

- "**Abortive:** No significant atrophy or weakness occurs after the fever, sore throat, headache and upper body stiffness were experienced" (Steadward, 1998:153).
- "**Non-paralytic:** Central nerve system is involved, but no permanent damage of the motor cells is experience. General and specific pain of acute contractions are experienced in muscle groups located in the upper or lower extremities, neck or back" (Steadward, 1998:153).
- "**Paralytic:** This includes three distinct conditions:
    - Spinal poliomyelitis involves the upper and lower limbs, respiratory and trunk muscles;
    - Bulbar poliomyelitis affects respiratory muscles and may also affect circulation;
    - Spinal-bulbar is the most serious form and affects both voluntary and involuntary mucles (Steadward, 1998).

Factors influencing fitness testing and exercise prescription for persons affected by poliomyelitis

According to Steadward (1998), there are four factors to consider when identifying appropriate tests and designing exercise programmes for persons affected by poliomyelitis.

1. **Disuse weakness:** Because some muscle functions are not working, there is the tendency to become less active and not use the muscle functions that are available. Through lack of use, weakness increases and more muscle function is lost.

2. **Overuse weakness:** Due to weakness in certain muscle groups, other muscle groups need to take over the work of this weak muscle group. This leads to overuse of the strong muscle group. Braces can help to decrease the strain and overuse of strong muscle groups.

3. **Work-rest intervals:** This is important for individuals with post-polio syndrome especially. There are certain times of the day that will be better for exercise and there is a certain pattern of rest periods that are optimal. This pattern will differ from individual to individual.

4. **Pain and sensation:** Cold temperatures and exercise can increase pain in joint and muscle areas.

Spina Bifida

Miller (1995) referred to spina bifida as "a condition in which one or more vertebrae fail to completely fuse on the posterior side during fetal development. The cause is still unconfirmed, but it is probably genetic, exacerbated by environmental factors" (p. 23). Spina Bifida develops between the 19th and 31st day of gestation. It is a congenital disorder of the spinal column caused by failure of one or more vertebral arches to close before birth. Cerebrospinal fluid forms a sac or tumor because of the protruding spinal cord. It has the same affect as a spinal cord injury on the movements of an individual (Steadward, 1998).

Types of Spina Bifida

The type of tissue that protrudes through the abnormal vertebra opening is used to categorised spina bifida:

- **Spina Bifida Occulta:** "The posterior elements or the spinous processes of the vertebrae fail to form. Lesion is fully covered by skin. This type of spina bifida does not cause neurological damage" (Steadward, 1998:158).

- **Meningocele:** "A sac containing skin, meninges, spinal fluid and at times nervous tissue protrudes from the spinal cord. This can be corrected shortly after birth, if there is no nerve damages" (Miller, 1995:23).

- **Myelomeningocele:** A portion of the spinal cord protrudes through an opening in the back of the vertebral column where the bone failed to form. It is the most serious form of spina bifida and causes permanent neurological damage ranging from mild to severe. Both motor and sensory nerves are affected (Miller, 1995; Steadward, 1998).

Factors influencing fitness testing and exercise prescription for persons with spina bifida

According to Steadward (1998), there are seven factors to consider when identifying appropriate tests and designing exercise programmes for persons with spina bifida.

1. **Paralysis of the trunk and lower limbs:** Level of paralysis depends on the level on the spinal cord protrusion.

2. **Hydrocephalus:** This is an abnormal accumulation of cerebrospinal fluid within the skull that causes the skull to enlarge. The pressure may cause mental deterioration, spastic paralysis of the lower limbs, and brain atrophy.

3. **Shunts:** A shunt is a surgically implanted tube that alleviates pressure on the brain caused by hydrocephalus. It functions to drain the excess cerebrospinal fluid. Activities that cause the individual to be inverted for along time are not recommended.

4. **Obesity:** This is a common condition among individuals with spina bifida.

5. **Bone deformities:** Weakness of the abdominal muscles combined with abnormally formed vertebrae may lead to spinal curvatures. Leg deformities can also occur.

6. **Loss of sensation:** If the individual has lost sensory function in a part of his/her body, burns, pressure sores and cuts can occur without the individual being aware.

7. **Braces/wheelchair:** Many individuals with spina bifida use braces to help support weak muscles. Many walk with assistive devices or use wheelchairs.

Multiple Sclerosis

"Multiple sclerosis is caused by patchy demyelination of myelin covering the central nervous system. Demyelination causes scar tissue to build up, producing lesions through the white matter of the brain and spinal cord and preventing message flow to various body parts" (Winnick, 1990:238). It is a neurological condition more common among females than males. The cause is unknown, but it is linked to immune dysfunction and influenced by genetic and environmental factors (Steadward, 1998).

Types of Multiple Sclerosis

Four basic types of Multiple Sclerosis have been identified by Steadward (1998).

- **Benign:** It starts with one or two attacks involving sensory abnormalities or optic neuritis. Good functional recovery is experienced, and individual can experience extended periods even decades without disability.
- **Remitting:** Several attacks are experience, with good functional recovery during the first 2-3 years. Relatively little disability is experience for many years.
- **Relapsing progressive:** The most common type of multiple sclerosis. The individual experiences exacerbations that remit only partially, if at all, with cumulative disability.
- **Chronic progressive:** Slow deterioration occurs without any remission.

Factors influencing fitness testing and exercise prescription for persons with multiple sclerosis

According to Steadward (1998), there are seven factors to consider when identifying appropriate tests and designing exercise programmes for persons with multiple sclerosis.

1. **Exacerbation:** During periods of degeneration, exercise and fitness testing should be avoided and only necessary activities performed.

2. **Environmental factors:** Warm environment accelerates the onset of fatigue and should be avoided. This includes bathing and swimming in warm water.

3. **Uhthoff's Phenomenon:** Exercise can lead to deterioration in vision. This deterioration should be reversed with rest or a proper post-exercise cool-down.

4. **Fatigue**: Fatigue is common and extended rest periods need to be provided.

5. **Coordination:** Closed kinetic exercises and tests are recommended due to the negative influence that multiple sclerosis has on balance and coordination.

6. **Flexibility:** Since the individual tends to be inactive, flexibility is lost. Flexibility is therefore important in any exercise programme to minimize the negative impact of multiple sclerosis on functional capacity.

7. **Autonomic cardiovascular reflexes:** Some people experience abnormal heart rate and blood pressure responses during acute distress. Therefore, strenuous exercise programmes should be avoided.

Muscular Dystrophy

The ACSM (1997) categorises muscular dystrophy in the family of hereditary diseases in which the primary pathology is within the muscle cell. It is recognised by the progressive deterioration of muscle strength, endurance and power. Miller (1995) refers to muscular dystrophy as "a group of chronic diseases that result in the progressive degeneration of skeletal musculature. The age of onset, rate of progression and the muscle groups affected, vary according to the type of disease. It is non-curable and non-contagious" (p. 27). "Muscular dystrophy is characterised by muscle weakness, contractures and deformity. It is progressive with pathological, biomechanical, and electric changes in muscle fibres" (Steadward, 1998:149).

Types of muscular dystrophy

Nine different types of muscular dystrophy have been identified. They have been described as follows (Winnick, 1990; Miller, 1995; Steadward, 1998).

- **Duchenne:** This is the most common and severe type of muscular dystrophy that usually starts at the age of three and by the age of 10 the individual is in a wheelchair. Males are more often affected than females.
- **Fascio-Scapular-Humeral:** This is the most common type of muscular dystrophy in adults. Normal life span is expected. Progressive weakness in the shoulder and facial muscles is experienced.
- **Limb Girdle:** This type of dystrophy usually occurs between ages 10 – 20 years. The individual has difficulty raising arms above shoulders and weak hip flexion and extension due to muscle weakness is experienced.
- **Becker:** This type affects only males between the ages 15 – 25 years. There is less pronounced weakness than with other types of muscular dystrophy and normal life span is expected.
- **Myotonic:** This type typically develops between ages 20 and 35 and is characterised by slow progression. Early signs are myotonia and facial weakness.
- **Congenital:** This type is present at birth and the most active phase occurs during fetal life. Characteristics are hypotonia, muscle weakness and contractures.
- **Opthalmoplegic:** This type appears during adulthood and affects the extraocular and swallowing muscles.
- **Distal:** This is the rarest form of muscular dystrophy and it affects the muscles of the extremities.
- **Ocular:** This type develops during adulthood and affects only the extraocular muscles

Factors influencing fitness testing and exercise prescription for persons with muscular dystrophy

According to Steadward (1998), there are six factors to consider when identifying appropriate tests and designing exercise programmes for persons with muscular dystrophy.

1. **Contractures:** Exercise decreases the incidence of contractures, which helps the person more in daily tasks than would be possible without exercise.

2. **Flexibility:** Persons with muscular dystrophy need to stretch the joints and ligaments, especially when starting to use a wheelchair. Lack of mobility can lead to a loss of flexibility, which in turn limits mobility even more.

3. **Balance:** Activities that require balance may become progressively difficult for individuals with muscular dystrophy. Support may have to be provided, or a change in activity may be necessary.

4. **Fatigue:** The use of rest intervals between different exercises is recommended. Winnick (1990) explained that it is thought that fatigued muscles allow greater amounts of the muscle enzyme creatine phosophokinase to escape into the bloodstream, thereby hastening the progression of the condition.

5. **Respiration:** Weak posture can have a negative influence on breathing. Exercises that improve posture and breathing should be incorporated in any programme.

6. **Performance limitations:** Balance, strength, ability to stand up and climb are often impaired.

Cerebral Palsy

Cerebral palsy is the label used to identify a group of neuromuscular disorders caused by damage to motor areas of the brain. Horvat (1990) described cerebral palsy as "a group of conditions that originate in infancy and are characterized by weakness, paralysis, lack of coordination and motor functioning and poor muscle tone directly related to pathology of the motor control centres of the brain" (p. 205). These conditions may occur in different degrees of severity. It is a non-progressive but lifelong impairment of movement and coordination that develops before, during or immediately following birth. Cerebral palsy results in delayed development of postural control, abnormal posture and muscle tone, contractures and decreased joint range of motion. Secondary orthopaedic problems can be caused by adaptive movement patterns. Damage to the brain is rarely restricted to one area of the brain, and therefore, a range of other conditions such as speech and language disorders, sensory impairments, seizures and mental impairments can occur (Winnick, 1990; Miller, 1995; Steadward, 1998).

Types of cerebral palsy

The different conditions that characterise cerebral palsy can be described accordingly to which body areas are affected (Winnick, 1990; Steadward, 1998; Horvat, 1990):

- **Monoplegia**: Only one limb is affected.
- **Paraplegia:** Only the lower part of the body is affected.
- **Diplegia:** There is major involvement of the lower limbs and minor involvement of the upper limbs.
- **Triplegia:** Three limbs are involved (usually one upper limb and both lower limbs).
- **Hemiplegia**: Involvement affects one upper and lower limb on the same side of the body.
- **Quadriplegia:** There is major involvement of all four limbs.

- **Double hemiplegia**: All limbs are affected, but the upper limbs more involved than lower limbs.

Cerebral palsy can also be described according to the impact it has on motor control. There are six different types of motor impairment that describe the manner in which motor coordination is affected (Winnick, 1990; Miller, 1995; Steadward, 1998).

- **Spastic**: Spasticity results from damage to motor areas of the cerebrum. It is "characterized by increased muscle tone, primarily of the flexors and internal rotators, which may lead to permanent contractures and bone deformities" (Winnick, 1990:230). Tendon reflexes are easily excitable and exaggerated stretch reflexes are usually present. The range of motion in affected joints gradually decreases with lack of use. Horvat (1990) noted that spasticity affects the flexor muscle groups that contribute to the maintenance of posture. A degree of intellectual impairment, "crossed eyes" and low body weight commonly occur with spastic cerebral palsy (Steadward, 1998). If muscles of the upper limb are prone to spasticity, the shoulder will be adducted, the arm will be carried toward the midline of the body, and the forearm will be flexed and pronated. The wrist will be hyperflexed and the hand will be fisted. Hip flexion, thigh toward midline, knee flexion, plantar flexion are characteristics of spasticity in the lower limbs" (Winnick, 1990:230).

- **Athetoid:** Winnick (1990) and Horvat (1990) reported that athetosis is the result of damage to the basal ganglia, which results in an overflow of motor impulses to the muscles. Excessive, involuntary movements and fluctuations between high and low muscle tone are characteristics of athetoid cerebral palsy. All four limbs usually affected (Steadward, 1998). Horvat (1990) described individuals with athetoid cerebral palsy as constantly moving, but with a lack of control and selectivity in movements.

- **Ataxic:** Ataxia is the result of a lesion in the cerebellum. The cerebellum is the portion of the brain that organises information to coordinate movement and is one of the primary feedback mechanisms for locomotion and balance control (Horvat, 1990). Ataxia is evident when an individual attempts to walk. They will be unsteady because of balance difficulties and will lack the coordination of arm and leg movements (Winnick, 1990). Limited spatial and kinesthetic awareness accompany ataxia (Steadward, 1998).

- **Tremor:** The tremors that may accompany cerebral palsy are the result of damage to the basal ganglia. This damage results in involuntary rhythmic movements. Tremors can be classified as non-intentional or intentional. With non-intentional tremors, the involuntary movement is continuous. With intentional tremors, involuntary movements only occur when a voluntary movement is attempted. Individuals with these tremors have greater success performing gross motor activities than they do fine motor movements that require precision (Winnick, 1990).

- **Rigid:** Rigidity is associated with diffuse damage to the brain rather than damage to any specific area (Winnick, 1990). Rigidity is characterised by minimal elasticity in muscles due to increased muscle tone in both agonist and antagonist muscles. This type of cerebral palsy is often associated with intellectual impairment (Steadward, 1998).

- **Mixed:** An individual who possesses two or more of the different types of cerebral palsy are described as having "mixed" cerebral palsy (Winnick, 1990). The most common "mixture" is manifested as quadriplegia and is the result of the combination of spasticity and athetosis (Steadward, 1998).

Factors influencing fitness testing and exercise prescription for persons with cerebral palsy

Miller (1995) emphasised that modifications in exercise programmes should be customised to accommodate each individual's specific "shortcomings." In other words, the specific disorder determines what type of modifications needs to be made. For example, individuals with spastic cerebral palsy will benefit most from large, slow and rhythmical moves during warm-up. Because of the constant movement of individuals with athetoid cerebral palsy, they remain habitually warmed-up and their warm-up period should focus on relaxation and stress reduction, which may enhance movement patterns during subsequent exercise.

Despite the need to customise testing and exercise programmes, the muscle cells of persons with cerebral palsy are normal and therefore they can adapt to exercise training. According to Steadward (1998), there are eight factors to consider when identifying appropriate tests and designing exercise programmes for persons with cerebral palsy.

1. **Motor coordination:** Persons with cerebral palsy may have difficulty with reaching, grasping and releasing of objects. Maintaining balance, controlling speed of movement and moving only isolated body parts can be difficult. Visually tracking objects can also be a problem.

2. **Speech:** More than 50% of persons with cerebral palsy have difficulty with speech, which has direct implications for communication, and also could have had an impact on the self-confidence of affected individuals.

3. **Convulsive disorders:** Because convulsions are a possibility, any testing or exercise area must be free from unnecessary clutter. Strapping techniques when performing some exercises can increase safety, e.g. using Velcro straps to secure light weights to the hands.

4. **Intellectual impairment:** Careful explanations and demonstrations of exercises will help limit the impact of possible intellectual involvement on the individual's ability to understand exactly what he/she is supposed to do.

5. **Surgery and braces:** It is possible that an individual has had surgery or uses braces in an effort to minimise the impact of cerebral palsy on motor performance. A record should be kept of this information so that testing and programme prescription can take into account either the change in movement potential provided by the surgery, or the impact of the brace(s) on performance.

6. **Fatigue and spasticity:** Spasticity may restrict the athlete's ability to release objects, which will influence activities in which objects are placed in the hands.

7. **Muscle balance and control:** Difficulties in muscle balance and control do occur, which can lead to difficulties in attempts to perform movements quickly or to change direction.

8. **Abnormal reflexes:** Excitement, distraction, anxiety and loss of balance can result in abnormal reflexes. A well-organised routine in a structured environment is recommended to minimise extraneous movements.

Traumatic Brain Injury

Traumatic brain injury is the result of an accident or any other trauma where the brain is permanently damaged. Brain damage as a result of head injury can be caused by primary trauma and further complicated by secondary responses to that injury. Head injuries can result in a combination of physical, cognitive, sensory and behavioural impairments. Due to the various regions of the brain that can be affected to different extents, the symptoms of traumatic head injury can vary from person to person (Miller, 1995). Because individuals with traumatic brain injury have similar motor characteristics as persons with cerebral palsy, much of the information about cerebral palsy will also apply to traumatic brain injury (Steadward, 1998).

Types of traumatic brain injury

Because brain injuries are similar to cerebral palsy, the descriptions of the different types of cerebral palsy are often applied to individuals with brain damage. Miller (1995) identified the two different causes of traumatic brain injury. Knowledge of the cause of an injury may provide insight into the emotional context of an individual's efforts to adapt to this acquired disability.

1. **A closed brain injury:** A closed brain injury can occur when some external force imposes acceleration, deceleration or rotational forces on the brain. Because the inside of the skull is not smooth, a tearing, shearing and bruising of brain tissue can occur when the external forces cause the brain to move within the skull.

2. **An open brain injury**: An open brain injury can occur when some external object passes through the skull and penetrates the brain. In addition to the damage done to the tissue directly impacted by the object, secondary brain damage occurs from the swelling, fever, increasing intracranial pressure, and ischemia of the brain that accompany brain penetration.

Factors influencing fitness testing and exercise prescription for persons with brain injury

Steadward (1998) identified six factors to consider when identifying appropriate tests and designing exercise programmes for persons who have had traumatic brain injury.

1. **Depression:** Depression is common among individuals with traumatic brain injury. This may make it difficult to for them to perform to their capabilities either during a test or an exercise session.

2. **Agression:** Exercise can be used as an outlet for the anger and frustration experienced by many individuals with traumatic brain injury. However, aggressive behaviour is not unusual and can cause problems in sport and exercise settings.

3. **Spasticity:** Spasticity is a common occurrence that can have a negative impact on performance. If severe spasticity occurs, it should be noted in the individual's file. Taking the person through correct stretching techniques before exercise can decrease the appearance of spasticity.

4. **Visual problems:** Visual problems can complicate and individual's efforts to perform certain activities. These problems can affect balance as well as any hand-eye or foot-eye coordination tasks. Testing and exercise or sporting activities may have to be modified to accommodate difficulties in seeing or in processing visual information.

5. **Vestibular dysfunction:** Disruptions of the vestibular system can lead to gait ataxia, eye-head coordination, and equilibrium problems. Exercises that call for balance, locomotion, and changes in body position can become extraordinarily difficult to perform.

6. **Communication disorders:** Because damage to the brain can impair the brain functions of memory, problem solving, language and attention, it may be difficult to sustain communication with persons with traumatic brain injury. They may have difficulties in remembering directions, acting in a logical manner, using "common sense," speaking and paying attention. They may need close and sustained supervision to ensure they follow a programme safely.

Other Neuromuscular diseases

There are other neuromuscular diseases that result in a physical disability. Because persons with these diseases may want to participate in sport and exercise programmes, it is important to highlight the implications for physical activity for the most commonly occurring ones.

Friedreich's Ataxia: This is an inherited condition and usually manifests itself in childhood and early adolescence. Characteristics are progressive degeneration of sensory nerves of the limbs and trunk that may progress in either a slow or a rapid manner. Poor balance and lack of limb and trunk coordination, resulting in clumsiness (Winnick, 1990; Miller, 1995).

Guillain-Barrè Syndrome: This is an acute and progressive neurological condition. Initial symptoms include symmetrical weakness, fatigue and numbness and tingling in the lower extremities (Winnick, 1990). Miller (1995) defined it as a disease that paralyses peripheral nerves.

Osteogenesis Imperfecta: This is also known as brittle bone disease. It is an inherited condition in which the bones are imperfectly forhed as a result of a defect in the protein matrix of collagen fibres. This condition produces a weak bone structure that results in bones that are easily broken (Winnick 1990).

Fitness Testing and Individuals with Physical Disabilities

Testing is a critical source of information when evaluating an individual's current level of physical fitness as well as when developing individualised training programmes to improve fitness (Marchant, 1996). The specific uses of test results have been well documented (AAHPERD, 1980; Strand & Wilson, 1993; Watson, 1995; Bar-Or, 1996; Pyke, 2000):

- **To identify weaknesses in one or more fitness components**: When weaknesses are known, a plan can be developed to address the weaknesses and hopefully, to improve the individual's performance capabilities.

- **To evaluate a training programme**: Testing and re-testing can document the success of a programme designed to improve a particular component of fitness. If the improvement is not satisfactory, the programme probably needs to be adapted.

- **To motivate an individual to become more fit:** If an individual has a specific score on a specific fitness component, he/she can set a specific goal for improvement (which will be measured by an improvement in score). In this way, testing not only supports goal setting, but re-testing also serves as a source of specific feedback about the success of participation in a fitness programme.

- **To educate about the importance of fitness:** A testing programme identifies specific fitness components that are important if an individual is to achieve maximum movement potential. It provides individuals with an understanding of their physical capabilities.

- **To predict performance potential:** Success in certain sports is influenced by selected genetic factors for example, somatotype, height and the distribution of motor unit types. It is possible to identify which individuals have a "genetic advantage" in these sports with a series of physical fitness-related tests. This can be helpful information if an individual aspires to achieve world-class performance in one of these sports.

Although fitness testing for persons with physical disabilities is a critical dimension of helping them to achieve their maximal potential, it is not unique. It is equally important for persons without physical disabilities. Winnick and Short (1985) stated that participants with disabilities need not necessarily be separated from a testing group or have special test items created for them. This statement was supported by Seaman (1995). Huge differences in work capacity and physical fitness exist among individuals living under varying cultural and physical environmental conditions throughout the world (Larson, 1974), regardless of whether or not individuals with disabilities are included.

Separate testing may be more sensible when a person with a disability requires special equipment, a special test protocol, or a specifically trained test administrator. This can be the case, especially with some physical disabilities. When Winnick and Short (1995) worked on the development of a health-related fitness test for children with disabilities, they found that they needed to modify some of the tests for some of the different disability groups. They also found that some groups were unable to perform all of the tests and therefore those test items had to be eliminated from their test protocols. The Canadian Journal for Applied Physiology (1998) recommended that individual adaptations be considered when working with persons who have impaired intellectual functioning, problems with adaptive skill behaviours and physical restrictions.

Seaman (1995) cautioned that modifications in tests could result in non-valid tests. Modifications should only be made if it is physically impossible for an individual to complete the "normally administered" test item. It is recommended that if possible, test modifications should be limited to modifying the time, intensity, or duration of the item. When reporting the result the test administrator must note all substitutions and or modifications of the test item(s). The reliability of the test can also be a problem when testing persons with disabilities. Individuals with disabilities often exhibit variability over different trials in their performance. It is important to note that each individual is unique, and the professionals must strive to personalise the testing process (Seaman, 1995). For example, when working with a child with a neuromuscular disease, it is more important to test muscle function than cardio-respiratory function. This is because a neuromuscular disease usually affects muscle strength more directly than it does cardio-respiratory functions. An appropriate fitness programme would emphasise improving muscle strength, local muscle endurance, and peak mechanical power (Bar-Or, 1996). Personalisation of testing also may result in substituting more appropriate test items that measure the same fitness component, but in a way that is better suited to the person with the disability.

Compton et al. (1989) noted that the evolution of fitness testing for people with disabilities has incorporated attempts to develop standardised test protocols. Johnson and Lenderee published the first norms interpreting scores for persons with intellectual impairments in 1976 (Compton et al. 1989). Project UNIQUE (Winnick & Short, 1985) established norms for a variety of fitness measures for children ages 10 to 17 years with sensory and orthopaedic disabilities. The Brockport Physical Fitness Test (Winnick & Short, 2000) and Physical best and Individuals with Disabilities (Seaman, 1995) are all fitness assessment manuals designed to provide standardised measurement and evaluation instruments for evaluating persons with disabilities. Although the reasons for fitness testing and many of the tests are the same for persons with disabilities and the so-called normal population, there is recognition that some modification in protocols and interpretation of test results is often needed. Knowledge should be the basis for making those modifications and formulating guidelines for interpretations, the following section will discuss each of the standard components of fitness only in relation to physical disabilities.

The Components of Physical Fitness and Individuals with Physical Disabilities

The ACSM"S guidelines for exercise testing and prescription (1995) defined health-related physical fitness as including body composition (anthropometry), cardio-respiratory endurance, muscular strength, muscle endurance and flexibility.

> If children and youth reach standards associated with test items representing the physical fitness components like, aerobic capacity, body composition, flexibility, and muscular strength and endurance they will have attained levels of physical fitness, which are appropriate for a healthy life (Seaman, 1995:22).

These components of fitness were reflected in the content of Project UNIQUE (Winnick & Short, 1985) and the Brockport Physical Fitness Test (Winnick & Short, 2000). In the Brockport Test, Winninck & Short (2000) presented the components in three categories: aerobic functioning, body composition and musculoskeletal functioning. The musculoskeletal functioning category was further divided into muscular strength and endurance and flexibility/range of motion.

Anthropometry

Anthropometry is the science that deals with "the measurement of size, weight and proportions of the human body" (Pollock et al. 1995:174). It is a series of systematic measuring techniques that express quantitatively the dimensions of the human body (Malina, 1995). It involves the use of carefully defined body landmarks for measurements, and appropriate instruments. Body size and proportions, physique and body composition are important factors in physical performance and fitness (Maud & Foster, 1995). Heyward (1998:164) identified circumferences, skinfold thickness, skeletal widths and segment lengths to assess the size and proportions of body segments as the measurements needed for anthropometrical evaluation. This was support by Pollock et al. (1995).

Body shape plays a role in the self-selection of individuals for competitive sport. Although there may not be only one "perfect body shape" for most sport, there are certain body types that are best suited for specific sports. Three basic physique types have been defined: ectomorph, mesomorph and endomorph (Bloomfield: 1994). According to Watson (1995) changes in physique can be used to follow the progress of certain aspects of strength development. Body-Mass Index (BMI) can be calculated to describe an individual's physique as a quantitative value.

The primary importance of the evaluation of body composition is that excess body fat can be harmful to an individual's health (AAHPERD, 1995). Winnick and Short (1985) referred to body composition as the degree of leanness/fatness of the individual. They also noted that body composition was a factor in physical performance, as well as an indication of an individuals' health. Although body fat is ideally measured by using hydrostatic weighing methods, skinfold measurements are still acceptable. The determination of body composition is commonly utilised to describe and compare various groups of athletes, as part of the athletic profile (Lussier et al. 1983). Declines in sport performance with increasing fatness have been observed, and can be attributed to the fact that fat is an inert non-contribution load, offering no assistance to the mechanics of movement. An excess of fat also will generally lead to the earlier onset of fatigue (Woolford, 1993).

Anthropometry and individuals with physical disabilities

Mean values for BMI for both paraplegic and quadriplegic individuals have been reported to be at or close to the range reported for the lowest health risk category (BMI range 20-25) (Manns & Chad, 1999:1569). However, low levels of physical activity have been a major contributing factor in the higher levels of obesity found generally among persons with disabilities (Compton et al. 1989). Individuals who are less severely impaired should be more similar to their able bodied peers regarding body composition or body fat, while those who have reduced muscle function may experience more difficult in achieving that goal (Winnick & Short, 1985).

Shephard (1998:126) stated that standard anthropometric measurement techniques and data interpretation were appropriate for application to individuals with most disabilities. Suggestions were made that for individuals with "unique physiques," skinfold results are to be used for re-evaluation of the athlete himself/herself rather than for comparison with norms. The rule when conducting skinfold measurements is to evaluate only skinfold sites where functional muscle exists. This applies to any anthropmetric measurements made by the fitness appraiser. When an individual suffers an incomplete lesion, measurements should be taken on the non-dominant side of the body. Girth measurements can be taken on both sides in order to identify asymmetric muscle development and functional mass. The type of cerebral palsy can affect skinfold and girth measurements. In hemiplegia, the affected side may be measured to monitor progress during the year or fitness program. Modifying standard body composition test may be necessary based on the individual's ability, ambulation mode, muscle spasticity and fatigue (Steadward, 1998).

Because obesity and coronary artery disease are common for people who use wheelchairs, skinfold measurements can be used to determine if an individual has gained fat or muscle weight. Shephard (1990) preferred skinfold readings to provide an indication of obesity rather than fat percentage. He noted that the changes in limb dimensions and bone density may lead to questions about whether the formulas for prediction of percentage body fat can be apply to paraplegia or other categories of disabilities. Winnick and Short (1985) found that children with spinal neuromuscular conditions had the largest skinfolds of all the orthopaedic impaired children they measured. Bulbilian et al. (1987) found an average fat percentage 22.3 % for persons with paraplegia.

Olle (1993) stated "many individuals with spinal cord injuries suffer from obesity due to decreased activity" (p. 706). Significant differences in percentage fat and total body fat were found between sedentary and physically active spinal cord injured individuals. The sedentary paraplegics had average fat percentage of 23.2 % and the active paraplegics 15.6% fat. Individuals with spinal cord injuries who use wheelchairs demonstrate "loss of muscle mass, changes in cardiovascular responses below the level of injury, and connective tissue changes associated with the absence of weight bearing on the lower limbs. These changes will have an impact on body water, bone density and muscle mass of the lower limbs" (Lussier et al. 1983:17).

Additional observations can be made about anthropometry and individuals with disabilities. In Project Unique, Winnick and Short (1985) found that the skinfold measurements of orthopaedic-impaired persons with cerebral palsy were similar to their peers without orthopaedic impairment. Test-retest comparisons with persons with musclar dystrophy indicate that anthropometric measurements may not directly reflect exercise benefits due to the degenerative nature of the disease (Steadward, 1998). Table 1 presents the key references that provide insight into the various anthropometric measurements that can be applied to individuals with disabilities.

Table 1. References for anthropometric measurements that can be applied to individuals with physical disabilities.

Measurements	Reference
Skinfolds Girth measurements of functional muscles Height & weight BMI	*The Canadian Journal of Applied Physiology* (1998), 23 (2): 126-139.
Triceps and subscapular skinfolds Height and weight	Winnick & Short (1985), pp. 9-26. *Project Unique*
Skinfolds BMI	Winnick & Short (2000), pp. 20-22 *Brockport Physical Fitness Test*
Triceps, subscapular and calf skinfolds Tricep skinfold only Calf and triceps skinfolds Height & weight BMI	Seaman (1995), pp.44-89. *Physical Best and Individuals with Disabilities*
Height	Bar-Or (1996), pp. 421-427. *Role of Exercise in the Assessment and Management of Neuromuscular Disease in Children*
Height & weight Somatotyping Wetzel Grid	AAPERD (1980), p. 25. *Special Olympics Instructional Manual*
Height & Weight Skinfolds Girths Circumferences Limb Widths	Australian Sports Commission (2000). *Physiological Tests for Elite Athletes*

Cardio-respiratory endurance

Winnick and Short (1985) provided the following definition of cardio-respiratory endurance: "It is the ability of an individual to perform large muscle or whole body activities continuously for a sustained period of time" (p. 37). This means that any test of cardio-respiratory endurance must meet the requirements for "large muscle" or "whole body activity" for a sustained period of time. Cardio-respiratory endurance is influenced by the ability of the body to obtain and use oxygen and by the ability of the body to rid itself of carbon dioxide (AAPERD, 1980). Oxygen consumption (measured as VO_2) is the product of the cardiac output and arteriovenous oxygen difference. VO_2 max is the maximum difference that can be achieved by an individual during a maximal test, and is commonly referred to as "aerobic capacity." VO_2 max decreases with age and males generally have higher VO_2 max values than females. VO_2 max values are due to a combination of genetic endowment and training (Davis, 1995; Withers et al. 2000). Either a direct or an indirect method of testing aerobic capacity can be used. With direct methods, sophisticated apparatus is necessary. Indirect methods either use less expensive apparatus or are field tests where the VO_2 max is estimated (Ward et al. 1995).

Cardio-respiratory endurance and individuals with physical disabilities

The amount of trainable muscle mass and impairments to the autonomic nervous system function may affect the capacity of persons with disabilities to participate in aerobic activities. For example, individuals with spinal cord injury usually have low muscle mass in lower extremities due to a reduction in circulation. Paralysis of the skeletal muscle in the lower extremities also means that the skeletal muscle pump will not function to assist with the return of blood to the heart. Blood pooling in the limbs is found and the stroke volume of the heart decreases. This does not mean improvement is impossible, however. Highly trained athletes with paralysis have exceeded the VO_2 max values achieved by their sedentary age-matched, able-bodied peers (Hooker, 1993; Miller, 1995).

When making test modifications and interpreting results, the individual's specific disability together with active muscle volume, venous pooling and other physiological and psychological influences must be taken into account. Irrespective of methodology, the aerobic test protocol should reflect the body's response to low exercise levels (Shephard, 1998). Muscle fatigue is one reason that individuals with disabilities may not perform to their aerobic capacity on cardio-respiratory fitness tests (Miller, 1995). Medication is another factor to consider. Medication that an athlete takes because of their disability may have an affect on cardio-respiratory response to exercise (Miller, 1995).

Although Stewart et al (2000) confirmed that VO_2 peak is an appropriate measure of fitness for persons with spinal cord injuries, Winnick (1990) emphasised that individuals with a spinal cord injury have reduced maximum uptake. One of the reasons for this is that oxygen uptake is directly proportional to the amount of muscle mass involved in an activity. If an athlete can use only his/her upper arms to propel the wheelchair, less muscle mass is involved than if an athlete can jog and use his/her leg muscles. This is also why the aerobic capacity of an individual in a wheelchair would be correlated to his/her muscular strength and endurance.

Steadward (1998) described several tests that could be used to determine the aerobic capacity of individuals with spinal cord injuries. The use of an arm crank ergometer or wheelchair ergometer was recommended. Another recommendation made by Steadward was the use of the Borg scale for Rate of Perceived Exertion (RPE). Research has shown that quadriplegic and paraplegic individuals (Glaser, 1985; Hoffman, 1986) and individuals who are intellectually impaired (Fernhall et al.1988) have cardiovascular levels lower than sedentary able-bodied individuals. Quadriplegic individuals have lower peak VO_2 values than paraplegic individuals (Manns & Chad, 1999). Arm exercise training adaptations are believed to be primarily peripheral in nature. This may result in increase of peak power output and VO_2 max of 10-20%. No changes in central cardiovascular adaptation to exercise training have been documented (ACSM, 1997). Cardio-respiratory implications for individuals with spina bifida are similar as for persons with spinal cord injury (Steadward, 1998).

"Individuals with poliomyelitis experience 20% lower oxygen consumption than their peers. The maximal heart rate is also 20 to 30 beats/minute less than what would be expected" (ACSM, 1997:194). "Oxygen uptake and associated cardiopulmonary values are significantly lower in individuals with post-polio syndrome than in age matched non-disabled individuals" (Steadward, 1998:154).

When testing an individual with multiple sclerosis one must take into account that local muscle fatigue may be the reason why an individual will stop during an aerobic capacity test. It is not necessarily the case that he/she is aerobically unfit (Steadward, 1998).

Various protocols can be used to assess aerobic capacity of individuals with cerebral palsy. Development of these protocols depends on the type and extent of the disability.

> The exercise mode to evaluate the cardiovascular fitness should be specific to the individual's primary ambulation mode. The accuracy of VO_2 max measurements is not compromised during wheelchair or cycle ergometer testing. Tests like a PWC_{170}, 12 Minute Cooper, Wingate Anaerobic Power Test and Bruce Treadmill test are recommended" (Steadward, 1998:144).

An individual with cerebral palsy needs more energy to perform a specific task than his/her able-bodied peer needs. This factor needs to be taken into consideration when testing and interpreting test results (Winnick & Short, 1985). "It has been found that individuals with cerebral palsy present higher heart rates, blood pressure, and lactate concentrations when performing at sub-maximal work rates than do their able-bodied peers. It has also been reported that their physical work capacity is as much as 50% lower than that of able-bodied peers" (ACSM, 1997:207).

Table 2 presents the key references that provide insight into the various measurements of cardio-respiratory endurance that can be applied to individuals with disabilities. It should be noted that for amputees, the site of an amputation would determine the type of cardio-respiratory test an individual is able to perform. For leg amputees the same tests can be used as recommended for individuals with paraplegia. For individuals with arm amputations, the same tests can be applied as are recommended for their able-bodied peers (Steadward, 1998).

Table 2. References for tests of cardio-respiratory endurance that can be applied to individuals with physical disabilities.

Tests	References
Adapted PWC 170 using arm crank ergometer and wheelchair ergometer 12 Minute wheelchair distance Test. (Track or on above ergometers.)	The Canadian Journal of Applied Physiology (1998), 23(2): 135-139, 148.
9 Minute/1 Mile run 12 Minute/1.5 Mile run	Winnick & Short (1985), pp. 9-26. *Project Unique*
PACER test (20m) PACER test (modified 16m) Target anaerobic movement test (TAMT) One-mile run/walk	Winnick & Short (2000), pp. 20-22 *Brockport Physical Fitness Test*
One Mile / 1.5 Mile run 9 Minute / 12 Minute run Distance run/walk in 6/9 Minutes 3 Minute step test Long distance run Aerobic movement 500-Yard Water Run Test PACER	Seaman (1995), pp. 44-89. *Physical Best and Individuals with Disabilities*
Walking tasks VO_2 Max 12-Minute wheelchair propelling	Bar-Or (1996), pp. 421-427. *Role of Exercise in the Assessment and Management of Neuromuscular Disease in Children*
Bench step 300-Yard run 600-Yard run/walk 6/9/12 minute Run 0.5/1/1.5 Mile Runs	AAPERD (1980), p. 25. *Special Olympics Instructional Manual*
Arm ergometer Cycle ergometer: Ramp protocol 6-12 minute walk Wheelchair ergometer Wheelchair treadmill Track distance with wheelchair 1 Mile walk	ACSM (1997), pp. 175-211. *Exercise Management for Persons with Chronic Diseases and Disabilities*
Treadmills Cycle-ergometer Kayak-ergometers Rowing-ergometers Multistage fitness test	Australian Sports Commission (2000) *Physiological Tests for Elite Athletes*

Flexibility

Flexibility is considered as one of the components of physical health, but its exact contribution to general health is even less clearly defined than its importance to athletic performance. Flexibility is defined as joint range of motion. An optimal range of motion in a joint is sport-specific and varies on an individual basis (Maud & Cortez-Cooper, 1995:221). According to Winnick and Short (1985) increased flexibility enhances performance in sport. They defined flexibility as "the component of physical fitness which refers to the range of motion around one or a sequence of joints, for example, the degree of stiffness or looseness of a joint" (p. 41). Horvat (1999) defined flexibility as the ability to move the body through a range of motions and the suppleness of the muscles and joints" (p. 277). AAHPERD (1980:20) note that flexibility is developed in activities that provide maximum range of movement in any given joint.

According to Gambetta (1999), "Flexibility in sport is not a static component but a dynamic controlling quality that allows the joint to go through as large a range of motion as can be controlled" (p. 12-13). He stated that flexibility must be combined with strength for skillful performance. He emphasised that dynamic flexibility is influenced by a variety of factors:

- Genetically determined elasticity and length of involved muscles and tendons.
- The structure of the joints involved.
- Basic coordination (to allow motor control of actions of the joints involved).
- The general fitness level of the athlete.
- The athlete's psychological/emotional state.

He also believed that because of the dynamic state of flexibility in sport, static tests of flexibility are not useful. Calder (2000) supported Gambetta's position and suggested that functional flexibility tests are preferred. This would require a performance analysis of the flexibility requirements of the specific sporting movements before determining which athlete should take which test.

Flexibility has been identified as one factor in an injury prevention strategy (Stopka, 1996). A positive correlation between muscle tightness, muscle strains and tendonitis were note by Calder and Sayers (1992).

Harvey and Mansfield (2000) have completed research that demonstrated that flexibility has an influence on the ability to produce maximal strength. Studies showed an improvement in one repetition maximum strength after 8 weeks on a flexibility program. Specific reasons for this improvement were not well documented, but a possible explanation can be the availability of free intracellular Ca^{2+}. Another possibility is that increased flexibility in a joint supports more rapid contractions, for example, increased stride frequency during sprinting.

Performance benefits may be achieved when flexibility training produces an increase in elasticity of the muscles and tendons. This improves the capacity of the muscles and tendons to utilise elastic energy during the movement, which can enhance the total force (Wilson, et al. (1991). Harvey and Mansfield (2000) emphasised that flexibility is joint specific, and selection of test type must take into account.

Flexibility and individuals with physical disabilities

The flexibility of individuals with handicapping conditions is generally inferior to that of their able-bodied peers (Winnick, 1990). Steadward (1998) noted that flexibility tests should be selected according to an individual's level of injury as well as condition of contracture or spasticity. Testing should be used to encourage the improvement of flexibility, not only in the joints that are used for the particular sport, but also the joints and muscles that are paralyzed. Flexibility is believed to help prevent injuries, pressure sores, and contractures, while maintaining functional ability, good joint range of motion and improved circulation. Modifications may be necessary when selecting appropriate tests, for example, the sit and reach test is not recommended for use with persons with high level lesions (Steadward, 1998).

It is generally recommended that individuals with spina bifida do the same tests that individuals with spinal cord injury do (Steadward, 1998). Steadward (1998) emphasised the importance of measuring the flexibility of an individual with muscular dystrophy because there is a decrease in flexibility as the muscles begun to weaken and atrophy. Testing can be used as a means for monitoring this progressive limitation on the range of joint motion.

For individuals with cerebral palsy, flexibility exercises should be focused on the tight muscle groups (Steadward, 1998:144). Flexibility is a critical objective in the physical development program of individuals with cerebral palsy. They generally lack adequate flexibility, and this condition limits their motor performance (Winnick & Short, 1985).

Individuals with orthopaedic impairments may have difficulty – or even be unable - to move particular joints through their full ranges of motion. This has a negative impact on their ability to perform (Winnick and Short, 1985). The site of an amputation will determine which tests of flexibility are appropriated, for example, the sit and reach test can be adapted for any type of amputation, although careful notes need to be kept regarding the exact modifications made (Steadward, 1998). Table 3 presents the key references that provide insight into the various measurements of flexibility that can be applied to individuals with disabilities.

Table 3. References for flexibility measurements that can be applied to individuals with physical disabilities.

Tests	Reference
Modified sit and reach Goniometer or flexometer readings of functional joints.	*The Canadian Journal of Applied Physiology* (1998), 23 (2): 127, 140.
Sit and reach	Winnick & Short (1985), pp. 9-26. *Project Unique*
Back saver sit and reach Shoulder stretch Apley test (modified) Thomas test (modified) Target stretch test (TST)	Winnick & Short (2000), pp. 20-22. *Brockport Physical Fitness Test*
Shoulder stretch V-Sit & reach Sit and reach Back-saver sit and reach	Seaman (1995), pp. 44-89. *Physical Best and Individuals with Disabilities*
Back lifts Leg raise Trunk flexion Head chest raise Lateral bend	AAPERD (1980), p. 25. *Special Olympics Instructional Manual*
ROM Goniometer measurements of: shoulder, elbow, wrist, knee, ankle and other affected joints Sit and reach	ACSM (1997), pp. 175-212. *Exercise Management for Persons with Chronic Diseases and Disabilities*
ROM Goniometer measurements of passive and active flexibility of all major movements in the shoulders, knees, hips and ankles Sit and reach	Australian Sports Commission (2000) *Physiological Tests for Elite Athletes*

Strength

Winnick and Short (1985) defined strength as "the amount of force that can be exerted by one or a group of muscles in a single contraction" (p. 32). This was supported by Horvat (1990). Kraemer and Fry (1995:115) defined strength as "the maximal force a muscle or muscle group can generate at a specified or determined velocity" (p. 115). Most sporting movements rely on the development of isoinertial force.

> Isoinertial force is developed during acceleration and deceleration of a constant mass about associated joints or articulations. Therefore the assessment of the ability of an individual to generate isoinertial force is important. The test to determine the strength of an athlete should correlate highly with the dynamics of the sport performance (Logan et al. 2000:200).

Isometric testing, isokinetic dynamometer testing, resistance machine testing or free weight testing can be used to determine strength. One, six or ten repetition maximum tests can be done with free weights or resistance machine testing to determine strength (Harman, 1995). Strength is related to power (strength x speed = power) and therefore dynamic athletic performance (Wilson, 1993; Steadward, 1998).

Strength and individuals with physical disabilities

When testing individuals with disabilities, strength is particularly important in the muscles that are involved with the mode of ambulation: the upper body for users of wheelchairs and the legs for persons who are walking (Winnick & Short, 1985). Individuals with spinal cord injuries who develop sufficient upper body strength are able to perform their activities of daily living with less effort than those who do not develop their strength (Wiese and Robberts; 2000:43). Winnick (1990) specified that the following muscle groups should be trained for individuals with quadriplegia: anterior deltoids, biceps, and lower trapezius. For individuals with paraplegia, he specified: all muscle groups as for quadriplegia, as well as pectoralis, triceps and latissimus dorsi muscle groups.

Many individuals with spinal neuromuscular conditions exhibit muscular weakness and low endurance. They may also exhibit muscular imbalances and contractures in certain muscle groups (Winnick & Short, 1985). When Winnick and Short (1985) found that the children with spinal neuromuscular impairments compared more favourable to their non-impaired peers than did children with cerebral palsy on a test of grip strength. Shephard (1990) considered the handgrip force as a good predictor of body strength. A correlation of r=0.79 was found between dominant handgrip strength and upper body isokinetic force in individuals with spinal cord injuries.

Testing or exercising during an acute episode of poliomyelitis is not recommended. Exercise can injure the already paralysed muscle still more. Rest periods are very important when testing these individuals (Steadward, 1998). Because these individuals have fewer motor units that can be activated to generate muscle tension, they have a diminished capacity for muscle strength and endurance. Exercise places an additional burden on the remaining functional motor units, which causes a more rapid onset of fatigue (ACSM1997).

Steadward (1998) recommended frequent rest periods when testing athletes with multiple sclerosis. These athletes should perform tests or exercises slowly and continuously and focus on maintaining their strength through a full range of motion. Compton (1989) found that individuals with myelomeningocele, multiple sclerosis, rheumatoid arthritis and osteoarthritis had below normal muscular strength. The ability of an individual with muscular dystrophy to exercise is more often limited by his/her lack of muscular strength than by his/her aerobic capacity (ACSM, 1997).

Many muscle strength tests for able-bodied individuals can be adapted for individuals with disabilities. The use of Velcro straps, wrist and ankle weights, and adapted benches can be used when modifying test protocols. For stabilisation, the straps can be put around lower limbs or chest areas to support an athlete in a particular position. Because some athletes with disabilities may have difficulty in holding weights, straps can be wrapped around an athletes' hand to support his/her grip. Wrist or ankle weights can be used instead of free weights because they can be attached to a limb.

For persons with cerebral palsy, testing strength in the prone or supine position is recommended. The use of straps and support pads are important for those individuals who have coordination and balance problems. Testing of antagonist and agonist muscle groups will provide a measure of the between muscle groups that leads to optimal functioning (Steadward, 1998). Winnick and Short (1985) indicated that strength training programmes should also develop agonist and antagonist muscle groups in a balanced way. Spasticity and muscle weakness are two factors that contribute to impaired motor function.

Muscle hypertonia, hyperactive tendon reflex, and velocity dependent resistance to passive stretch are characteristics of spasticity. Greater spasticity exists in the hip adductors in individuals with cerebral palsy than in able-bodied children. Less abduction/adduction strength were also found in children with cerebral palsy in comparison with able bodies (Engsberg,J.R.. 2000:221,230-231).

Muscle balance is the relationship of an agonist muscle of a joint with the antagonist of the joint or the relationship of the left side to the right side. An example of an agonist versus antagonist muscle is the quadriceps and hamstring muscles at the knee joint. The relationship of the concentric force versus the eccentric force of the same muscle group can also be seen as muscle imbalance. Testing to assure muscle balance for persons with amputations is very important. It is important to decide whether the amputees who wear prosthesis should be tested while wearing it or not. The test conditions should be noted so that any re-test is performed under the same conditions (Steadward, 1998; Winnick &Short, 1985). Table 4 presents the key references that provide insight into the various measurements of flexibility that can be applied to individuals with disabilities.

Table 4. References for measurements of strength that can be applied to individuals with physical disabilities.

Tests	Reference
Handgrip Isokinetic dynamometers Bench press Free weights (1 RM, 8 RM, 10 RM)	The Canadian Journal of Applied Physiology (1998), 23 (2): 127,135,143,144.
Grip strength	Winnick & Short (1985), pp. 9-26. *Project Unique*
Dominant grip strength Bench Press Dumbbell Press Reverse curl Wheelchair ramp test	Winnick & Short (2000), pp. 20-22. *Brockport Physical Fitness Test*
Hand Grip Strength Bench Press	Seaman (1995), pp. 44-89. *Physical Best and Individuals with Disabilities*
Knee extension (6 RM) Elbow extension (6 RM)	Bar-Or (1996), pp. 421-427. *Role of Exercise in the Assessment and Management of Neuromuscular Disease in Children*
Hand grip Isometric tests & Isokinetic tests Tensiometer	AAPERD (1980), p. 25. *Special Olympics Instructional Manual*
Isotonic & Isokinetic testing of shoulders, legs, hips and arms Free weights	ACSM (1997), pp. 175-212. *Exercise Management for Persons with Chronic Diseases and Disabilities*
Seven Stage abdominal test Squat & Bench press Grip strength Isokinetic dynamometer Lat pull downs	Australian Sports Commission (2000). *Physiological Tests for Elite Athletes*

Muscular endurance

Muscular endurance refers to the ability to repeatedly perform sub-maximal muscular contractions. Unlike activities that promote cardio-respiratory endurance, activities to promote muscular endurance must target specific parts of the body (Winnick & Short, 1985). Muscle endurance is closely related to muscle strength. It is developed in activities where "a maximum number of repetitions are performed against a fixed resistance" (AAHPERD, 1980:20). Horvat (1990) defined muscular endurance as "the muscles' ability to work against resistance for a prolonged period" (p. 268). Often the terms "dynamic strength" and "muscular endurance" are used interchangeably. Dynamic strength is defined as "the ability of the individual to move, lift or support the weight of the body. When such strength is required to function for a lengthy time in a strenuous and exerting manner its overall capacity is influenced by muscular endurance" (Larson, 1974:364). If all other factors are equal, a stronger muscle will have more muscle endurance than a weaker muscle. This is because the onset of fatigue is delayed in a stronger muscle because activity uses a smaller percentage of the maximum strength of the muscle (Bloomfield et al. 1994).

Muscle endurance and individuals with physical disabilities

Muscle endurance is generally lower for individuals with disabilities when compared to their able-bodied peers. This is true despite the fact that - except in the case of muscular dystrophy – "their muscle physiology is normal and their muscles will respond appropriately to training as long as innervations are intact" (Winnick, 1990:308). For individuals who use wheelchairs, muscle endurance testing should focus on the shoulders and training programmes should develop proper muscle balance. Individuals who use wheelchairs normally develop stronger anterior shoulder muscles and these muscles are not in proper balance with the posterior shoulder and back muscles (Steadward, 1998).

For persons with cerebral palsy, muscle endurance is often tested in the prone or supine position and testing includes an assessment of balance in the antagonist and agonist muscle groups (Steadward, 1998). Table 5 presents the key references that provide insight into the various measurements of flexibility that can be applied to individuals with disabilities.

Table 5. References for measurements of muscle that can be applied to individuals with physical disabilities.

Tests	References
Bicep curls Push-Ups Sit-ups Bench Press	*The Canadian Journal of Applied Physiology* (1998), 23 (2) pp.127-135,144.
Sit-ups – 1 minute Flexed arm hang	Winnick & Short (1985), pp. 9-26. *Project Unique*
Trunk lift Push-ups Seated push-up Curl-ups Modified Curl-ups Extended arm hang Flexed arm hang Pull-up Modified Pull-up Isometric push-up	Winnick & Short (200), pp. 20-22. *Brockport Physical Fitness Test*
Curl-up Sit-ups Modified Pull-Up Knee Push-up Flexed arm hang Isometric Push-up Chair Push-up	Seaman (1995), pp. 44-89. *Physical Best and Individuals with Disabilities*
None	Bar-Or (1996), pp. 421-427. *Role of Exercise in the Assessment and Management of Neuromuscular Disease in Children*
Curls Isokinetic tests Leg lifts Sit-ups V-sit	AAPERD (1980), p. 25. *Special Olympics Instructional Manual*
Maximum repetitions at 60% voluntary contraction	ACSM (1997) *Exercise Management for Persons with Chronic Diseases and Disabilities*
Chin-ups	Australian Sports Commission (2000). Physiological Tests for Elite Athletes

Power

Power represents the coordinated application of strength. Power is the capability to generate force and it is highly related to successful performance in many sports. "Acceleration of an object is proportional to the force acting on it divided by its mass. Thus if you can exert force in "explosive" sports you would be able to accelerate an external implement and achieve better results" (Harman, 1995:87). Power is generally defined as the amount of force that can be exerted by a muscle or a muscle group in a specific length of time. Power is a combination of speed and strength, which is why it is not always identified as a separate component of physical fitness.

Power actually has three components that can be measured: power-strength, power-endurance and power-speed (Winnick & Short; 1985). Miller (1995) defined power as the speed or rate of a muscular contraction. Power requires that force be generated quickly. The contractions of the muscles are short bursts of explosive activity. The rate at which work can be done is sometimes referred to as power. Power is the amount of work done in unit time. Power in sport is dependent on the development of strength and speed.

> Power output is equal to force times speed, and it reaches a maximum at about one third of the maximum speed. Maximum power can only be developed for a few seconds because energy stores in the muscle needed for power are rapidly depleted and less efficient sources of energy must then be employed (Watson, 1995:58-59).

Power is developed in activities that are explosive in nature where maximum force is released at a specified moment. "Jumping, certain types of throwing, and any activities that require quick, forceful movements encourage development of power" (AAPERD, 1980:20). Wilson et al. (1993) recommended that the best way to improve power is to train with weights that are 30% of maximum load (30 % of 1RM) in a full range of motion.

Power and individuals with physical disabilities

Individuals with cerebral palsy have difficulty developing speed, it is also difficult for them to improve their power and testing of their power is very difficult. Powerful movements demand coordination of the muscles and rapid contraction, which is not always possible for persons with cerebral palsy (Winnick & Short, 1985; Winnick, 1990). Persons with post-polio syndrome also experience a lack of power. This problem appears to be related to muscle weakness and deconditioning (ACSM: 1997). Table 6 presents the key references that provide insight into the various measurements of power that can be applied to individuals with disabilities.

Table 6. References for measurements of power that can be applied to individuals with physical disabilities.

Tests	References
Standing long jump Softball throw	Winnick & Short (1985), pp. 9-26. *Project Unique*
Wheelchair push/walk 40m	Winnick & Short (2000). pp. 20-22. *Brockport Physical Fitness Test*
Standing long jump	Seaman (1995), pp. 44-89. *Physical Best and Individuals with Disabilities*
Wingate anaerobic test.	Bar-Or (1996), pp. 421-427. *Role of Exercise in the Assessment and Management of Neuromuscular Disease in Children*
Mountain climber Squat jump Standing high jump Standing broad jump Vertical jump Medicine ball throw Softball throw Volleyball throw	AAPERD (1980), p. 25. *Special Olympics Instructional Manual*
Wingate	ACSM (1997), pp. 175-211. *Exercise Management for Persons with Chronic Diseases and Disabilities*
Vertical jump Counter movement jump One leg vertical jump Drop jump Isoinertial force-mass test Bench Throw Drop Bench Press Throw Seated Shot put throw 30 Sec Wingate cycle ergometer test Standing broad jump Overhead medicine ball throw Side arm medicine ball throw	Australian Sports Commission (2000) *Physiological Tests for Elite Athletes*

Sport-Specific Fitness Testing

The underlying concept of "health-related fitness" is that an appropriate level of fitness in each of the components is associated with a lower risk for the development of disease and/ or functional disability. If an athlete wants to compete successfully, however, higher levels of physical fitness are required and more specific tests items for measurement of the fitness components may be recommended (Maud, 1995). In a study by Judge and Potteiger (2000), a battery of tests was used to identify over-training in throwers. The fitness components measured were anthropometry and body composition, anaerobic power and capacity, upper body neuromuscular performance, leg extension and flexion strength, upper body repetition maximums and training volume. These were the fitness components identified as necessary for peak performance in throwing events, and they were also considered to be the fitness components most likely to be influenced by training.

Most of the physical fitness testing protocols for persons with disabilities was designed to evaluate health status or to evaluate to what extent a person was able to perform certain tasks (Seaman, 1995). Because the success of an athletes' training programme is largely dependent upon satisfying the performance aims associated with his/her sport (http://www.brainmac.demon.co.uk, 2001), it is critical to develop relevant sport-specific physical fitness testing protocols that can be used by coaches to guide athlete development. Bloomfied et al. (1994) suggested that performances would be improved considerably "if coaches were able to objectively assess the physical strengths and weaknesses of their own swimmers, as this would enable them to develop a stroke, which better suited their specific physical capacities (p. 40).

Bloomfield et al. (1994) found that even if athletes do have the skill necessary for competition, physical fitness components like body composition, strength and flexibility profoundly influenced skill application. When they completed a series of fitness tests and worked to improve fitness in "weak" components, the athletes' skill performance improved. For disability sport, the matter of identifying which fitness components are essential for which event is a bit more complex than it is in "able-bodied" sport. First, there must be an understanding of the functional movement capabilities of the individual athletes. Second, there must be an understanding of the movement mechanics (biomechanics) of the sport in relations to those movement capabilities. Only then can the guidelines for developing valid fitness testing protocols be attempted.

Functional Movement Capabilities and Classification in Sport for Individuals with Physical Disabilities

The classification of athletes into categories or "classes" to ensure equitable competition is the essence of disability sport. Classification is a continuous assessment and programming system that has equitable and fair competition as its goal. Classification involves the careful and precise evaluation of an athlete's capacity to perform skilled movement. Classification has been defined by Williamson (1997) as:

> ...the term use to describe the systematic process by which participants are objectively evaluated in relation to their impairment and or, sports potential for the allocation to a specific competition class, band, group or division for the conduct of a fair sports contest . The entire process is based upon a set of principles relating to the foundation, eligibility, assessment and characteristics of the process (p. 48).

The purpose of classification is to ensure that the winning or losing of an event depends on talent, training, skill, fitness, and motivation rather than differences among the nature and extent of their disabilities (Davis & Ferrara, 1996; Williamson, 1997; Sherrill, 1999).

Classification in disability sport started as early as 1948. Since 1984, the Paralympic Games have played a huge role in refining the classification system (Williamson, 1997). Highly qualified classifiers assign a classification code to each athlete based on his/her medical or vision status and his/her functional ability in relation to a particular sport (Sherill, 1999). Davis and Ferrara (1996:38-39) described medical classification as:

> ...a system that is solely based on an athlete's physical condition or nature of disability. Teams of classifiers composed of physicians and therapist attempt to verify minimum disability. It centred on the disability and not concerned with overall functional abilities of the athlete (pp. 38-39).

The functional classification focuses on determining the athlete's capabilities in relation to the requirements of specific sport skills.

The team of classifiers, who determine the classes for competition, is composed of a physician and a therapist, as well as a technical professional from the sport in which the athlete wants to participate. The physician and therapist complete the medical classification and the technician completes the sport classification – an evaluation of an athlete's sport-specific capabilities. There are two phases of sport classification. During the first phase, the classifier evaluates the athlete's strength, range of motion, motor coordination, and balance needed to perform the sport skill(s). During the second phase, the classifier evaluates the athlete's actual sport performance. The emphasis of the functional classification system is on the sport, not the disability (Williamson, 1997).

Research has been done on medical and functional classification in order to determine if it is effective in supporting more equal and fair competition (Dummer, 1999; Daly & Vanlandewijck, 1999; Wu & Williams, 1999). Williamson (1997) put the total picture of classification into a framework with four key process stages:

- Foundation.
- Eligibility.
- Assessment.
- Characteristics.

Table 7 identifies the principles that guide classifiers as they work through these four phases.

Classification for the sport of athletics is governed by the International Stoke-Mandeville Wheelchair Sport Federation (ISMWSF) classification system and the Cerebral Palsy – International Sport and Recreation Association (CP-ISRA) classification and sports rules manual. A primary classification is first assigned according to the disability presented by the athlete. This primary classification puts the athlete in a class according to his/her disability. For example, a person with cerebral palsy will be put into a class CP with a number next to it. The number indicates the severity of the disability. Each different disability has its own class and numbering system.

A sport classification system is then applied to the classification process. When competing in field events, athletes receive a classification according to their event and your disability and number. The "F" before an individual competing in athletics indicates that the individual is classified for the <u>field</u> events in that specific class. "T" in front of a number for an individual taking part in athletics will indicate that the athlete is classified in the <u>track</u> events in that category. Table 8 indicates the numbers for each of the sport classes in athletics.

Table 7. A summary of the basic principles that guide classification in competitive sport for participants with disabilities (adapted from Williamson, 1997:47).

	Stage	Principle	Explanation
Primary aspect of classification	Foundation	1 Sport specific	Classification must be sport-specific if it is to be valid.
		2 Viability	Any classification approach must be realistic in relation to the impairment group and movement potential to which it is relating.
		3 Disability parity	In combined classification approaches, the characteristics of the different impairments must be accounted for by the assessment.
	Eligibility	4 Qualified access	Although open access to competition is desirable classification must have a framework and criteria, which defines the eligibility of some impairments for sports.
		5 Safe involvement	Individuals must not endanger their health or the condition of their impairment because of contra-indicated or high-risk participation.
		6 Minimal impairment	A minimal level of impairment is set for a sport where alternative participation in the non-disabled sport could not happen with dignity or parity.
Secondary aspect of classification	Assessment	7 Objective testing	Testing procedures and the personnel involved must be informed, reliable, and unbiased.
		8 Co-interaction	The process of testing is interactive – both testers and participants must show mutual respect, cooperation and trust.
		9 Status protest and appeal	An individual's classification status can be protested or appealed due to observations and according to specific procedures.
	Characteristics	10 Class flexibility	To allow more opportunities for competition, classes may be split for specific events, athletes may compete "up or down," or classes may be combined for a specific competition.
		11 Borderline	It is accepted that some individuals will naturally be in either the lower and upper "borderline" zones in each classification category.
		12 Spread	Any particular class or division includes a spread of potential, which will lead to range in performances between the lower and upper "borderline" zones.
		13 Performance overlap	As a consequence of spread, an overlap of performances across class divisions can occur, especially between the higher levels of one class and the lower levels of another.
		14 Sports components	Irrespective of the impairment, common sports components of strength, speed, fitness, flexibility, and coordination should determine success.
		15 Review and modification	Any classification system must be adaptable and be reviewed regularly to ensure appropriate modifications.

Table 8. Numbers assigned to the different classes in athletics.

Number	Disability
11 12 13	Visual impairment
20	Intellectual impairment
31 32 33 34 35 36 37 38	Cerebral Palsy
40 41 42 43 44 45 46	Amputation
50 51 52 53 54 55 56 57 58	Spinal cord injuries, Poliomyelitis, Muscular Dystrophy, Multiple Sclerosis, Les Autres

The athletes competing in sitting throwing events, for example, will be classified as either an F31-F34, or F51-F58. When classifying athletes with cerebral palsy (31-38), functional ability is classified accordingly to the Ashworth scale for muscle tone (spasticity/stiffness)(see Table 9). When classifying athletes with spinal cord injuries, etc., the R.H. system is used to evaluate functional ability (see Table 10).

Table 9. TheAshworth scale for spasticity.

ASHWORTH SCALE	
Number	**Description**
0	No increase in tone
1	Slight increase in tone giving a "catch" when the limb is flexed or extended
2	More marked increase in tone, but limb is easily flexed
3	Considerate increase in tone with passive movement difficult
4	Limb rigid in flexion or extension

Table 10: The R. H. System for functional ability.

R. H. SYSTEM	
Number	**Description**
0-1	Nil (No movement)
2-3	Some (Against gravity)
4-5	Good (Against resistance)

Classifications of the athletes in this study

All of the athletes in this study participated in the sitting throwing events. Their primary classifications were either cerebral palsy or the broader classification associated with spinal cord injuries, les autres, etc. The following is a brief description of each of the sport classifications for the athletes with cerebral palsy:

- F31

  An athlete in this class displays severe quadriplegia with involvement in all four limbs. Spasticity is graded 4 and 3+ (with 4 the most severe). Poor functional movement and strength in all extremities (trunk included) is experienced. This athlete is unable to propel a wheelchair and is dependent on an electric wheelchair.

- F32

  An athlete in this class displays quadriplegia with spasticity graded 3+ and 3. More function is present in less-affected side than with athletes in F31, and the athlete is able to propel a wheelchair. Athletes in this class also can be divided according to lower and upper extremity involvement. If the upper extremities are more affected by the cerebral palsy, events that emphasize lower extremity function will be pursued, e.g. kick or ball thrust with feet. If the lower extremities are more affected by the cerebral palsy, events that emphasize upper extremity function will be pursued, e.g. the shot put, discus, or javelin.

- F33

  An athlete in this class displays quadriplegia or severe hemiplegia, with close to full function in his/her non-affected side. The legs are more affected, trunk control is fair and spasticity in the upper extremities is graded 3 or 2. Slow "grasp and release" hand movements are common.

- F34

  An athlete in this class displays diplegia, with minimal limitation or control problems in upper limbs and trunk. Spasticity in the lower extremities is graded 4 or 3, which means that the athlete is not able to walk.

The following is a brief description of each of the sport classifications for the athletes classified in the spinal cord injured, les autres, etc., classes who participated in this study:

- F51

  An athlete in this class has no grip with his/her non-throwing hand. The only fully functional muscles are elbow flexors and wrist dorsi-flexors. Shoulder weakness is common.

- F52

  An athlete in this class has difficulty gripping with non-throwing hand. He/she does have functional elbow flexors, extensors, wrist dorsi-flexors and palmar flexors. There is good shoulder muscle function. There is some finger flexion and extension.

- F53

  An athlete in this class has a nearly normal grip with the non-throwing hand. Full power is possible in the upper arms and shoulders. Finger flexion and extension is close to full power. No intrinsic hand muscles are functional.

- F54

  An athlete in this class has a fully functional upper body, but no trunk movement control is possible.

- F55

  An athlete in this class has normal upper limb function and some abdominal muscles and spinal extensors are functional. The hip flexors are non-functional. Athletes with bilateral hip disarticulation can also compete in this category.

- F56

  An athlete in this class functions similarly to an athlete in the F55 class, but his/her hip-flexors are also functional. Bilateral above knee amputees who chose to compete from a sitting position may seek to be classified in this class. For the above knee amputee, the length of the leg stump must be less than one-half of the length measured between the olecranon process of the elbow and the tip of the middle finger. Athletes who fit into this category should compete in class F56 for the javelin and shot put and in class F57 for the discus.

- F57

  An athlete in this class is an F56 athlete with functional values of 2's or 3's in his/her lower limbs. Athletes with bilateral above knee amputations or single hip disarticulation will fall into this class. For the above knee amputee, the leg stump should be greater than one-half of the length between the olecranon process of the elbow to the tip of the middle finger. These athletes will compete in the F57 class for javelin and shot put, an in the F58 class for discus.

- F58

  An athlete in this class is an F56 with functional values of 3's and 4's in the lower limbs. Amputees who chose to compete from a sitting position who have single above knee amputations or bilateral below knee amputations, also fall into this category.

Sport-Specific Movement Requirements

In addition to identifying the key components of physical fitness and the functional capabilities of the athletes who compete in the sitting throwing events, it is critical to examine the mechanics of the throwing events. Designing a sport-specific fitness testing protocol will be possible only when information from these three sources is coordinated (Strand & Wilson, 1995).

Mechanics of throwing

Adrian & Cooper (1995) described throwing as "the act of propelling an object through the air by means of the action of the body, climaxed by the arm and hand. The release is through extension or by whirling motion of the upper limb and parts of the body assisting in the action" (p. 333). The standard throwing events in track and field athletics are discus, shot put, javelin and hammer throw. In all these events, the objective is to throw the implement as far as possible within a given vector marked on the field. The athlete with the best technique, best physical condition and strongest mental skills should achieve the greatest distance.

According to Hay (1993) the distance achieved in the shot put is "equal to the sum of (1) the horizontal distance that the shot is in front of the inside edge of the stop board at the instant it is released, and (2) the horizontal distance it travels in the air" (p. 469). The position of the body position at the time of release, as well as the length of the body parts, play a role in achieving the largest horizontal distance in front of the inside edge of the stop board. Hay discovered during the 1987 World Championship that the distance in front of the inside edge of the stop board was as much as 17cm for the men and 11cm for the women finalists.

The maximum distance an object travels is not only influenced by the speed and angle of release and height at which the object is released. Aerodynamics plays a roll in the discus, javelin, and hammer throws Dyson (1975).

- Speed of release

  The speed at which the object is released is "the single most important mechanical factor influencing the distance the object is going to travel. It is determined by the magnitude and direction of the forces applied to the object and the distance over which these forces act" (Hay, 1993:470). Dyson (1975) described an efficient throw as:

> ...the one in which the athlete exerts the forces of his entire body over the greatest range practicable. The speed of release in throwing is directly proportional to the average force exerted through the implements center of gravity. Where all things are equal, the greater total body force produces the greater speed and therefore the longer throw. FORCE = mass x acceleration (p. 188)

In order to create speed of release, two physical fitness qualities are important for a thrower: strength and mobility. "Strength will influence the magnitude of the force and mobility, together with technique, will affect the range of the force action" (Paish, 1980:11).

A very important factor when creating maximum body force is that the forces generated by all the different body parts are directed in the direction in which the object is supposed to travel. The fast stretching and recoiling of the large muscle groups create these forces. Because the athletes with disabilities in this study do not have the use of their hips and lower body to create force, they must rely on the muscles of their upper body to create the forces needed to throw successfully.

Another factor mentioned by Northrip et al. (1977) and Dyson (1975) in efficient throwing is the sequence in which the forces are applied. The optimum results are obtained when all the body parts work together and are timed perfectly. Co-ordination requires both simultaneous and sequential patterns of contraction.

The final factor that influences the speed of delivery is the ground reaction force. This is a major concern when developing a chair/throwing stand for any athlete who competes from a sitting position. Because the athlete is not physically in contact with the ground, the chair/throwing stand must be firmly anchored. The chair must be built to allow the athlete maximum range of upper body motion.

- Angle of release:
  The angle at which the missile is released plays also a part in the distance the athlete achieves (Dyson, 1975). Because the height at which the object is released is higher than the landing point, the angle of release should be somewhat less than 45°. The height of release depends on the height of the athlete's throwing hand at delivery. For standing athletes, the muscles of the legs, trunk and throwing arms contribute to full body extension. For the sitting athletes in this study, the trunk and the arm muscles provide body extension. If other factors are equal during the throw, the athlete that attains full body stretch during the throw will achieve greater distances (Dyson 1975; Paish, 1980; Hay, 1993).

- Aerodynamics
  Because of their shapes, the discus and javelin throws are more affected by aerodynamic factors than shot put and hammer throw. The shape and size of the object influences the air resistance, and therefore the amount of kinetic energy that is lost during flight. Air resistance is also dependent upon the speed of the object. The greater the resistance, the greater the loss of kinetic energy, which means a loss of speed, which results in a shorter travel distance (Dyson, 1975).

  The stability of the object during the flight is important, and the athlete can control this with a smooth delivery and release. Another factor that influences the flight (especially with the javelin) is the material and shape of the object. The rules of each event determine these technical requirements (Paish, 1980).

The mechanics of the throwing events are summarised in Figure 1.

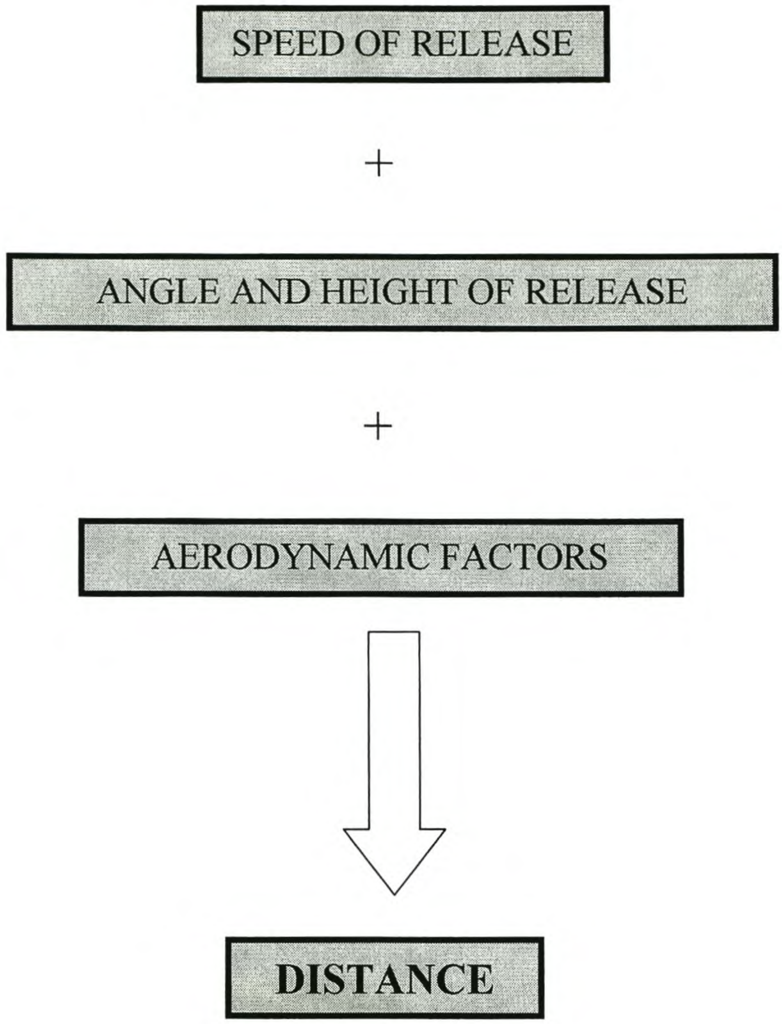


Figure 1

A Summary of the factors that determine distance achieved in the throwing events

Musculoskeletal involvement for throwing

Because this study was completed only with athletes who compete from a sitting position, the muscles of the shoulder girdle complex are the focus for fitness assessment and training.

- Bone structure
  "A total of 28 bones in the arm-shoulder area are use during any throwing action. The clavicle serves as a structional support during the action while the humerus, scapula, radius, ulna, proximal row of carpals, distal row of carpals, metacarpals and finally the phalanges are involved in the whole action. All

forces for the throws are characterized by medial rotation of the humerus and pronation of the forearm and hand" (Adrian & Cooper, 1995:335).

- Muscles involved

  "Because of the lack of stability in the shoulder joint, the rotator cuff muscles (subscapularis, supraspinatus, infraspinatus and teris major) are very important for stability. The other main muscles involving in not just stability of the shoulder joint but in the throwing action itself is: Pectoralis major, latissimus dorsi, deltoid, trapezius, serratus anterior, rhomboids, and levator scapula" (Adrian & Cooper, 1995:336).

Biomechanics of the three throwing events

The three main throwing events for persons competing from a sitting position are the shot put, javelin and discus. Adaptations of the throwing technique used by able-bodied throwers are necessary. For the purpose of this study, the biomechanics of able-bodied athletes were used to draw up a list of actions that happen during the throws. The run up and use of the circle are not included and only the delivery of the object is taken into account.

- Shot put

  Due to lack of abdominal stability, the amount of rotation which sitting athletes can achieve differs quite substantially from their able-bodied peers. The different disability groups have different degrees of functional abdominal muscles and therefore differences in their abdominal control. Some of the athletes are able to turn side-ways and therefore their abdominal muscles play an important role in developing speed for the release of the object. After the gliding phase, an able-bodied athlete uses his/her rear foot as a support and the front foot as an anchor as the trunk extends. "In the last phase of trunk rotation, there is adduction and flexion of the shoulder as the upper arm moves forward and upward. At the same time, the forearm extends, moving the forearm forward and counteracting the upward movement of the upper arm. The final action is hand flexion" (Adrian & Cooper, 1995:357-358). The ideal for a sitting athlete would be to copy the action as closely as possible.

- Discus

  To start the throwing action, the athlete swings the discus downward and backward to a position behind the body and somewhere between hip and shoulder level, twisting of the trunk to the right if possible, carries the discus still farther back. Forceful contraction of the abdominal muscles (if the athlete does have control of his/her abdominal muscles), pulls the shoulders forward. Some of the athletes do use their non-throwing arm to pull on the throwing chair in order to rotate their shoulders. The throwing arm that is left behind by this rotary movement of the trunk, is swept forcefully outward and forward and the discus is brought around to its point of release. The arm movement from the beginning to the end follows a spiral curving pathway. The hand grasp on the discus is firm during the initial phases but later in the throwing action, the upper edge of the discus drops away from the wrist (Dyson, 1975; Hay, 1993).

- Javelin

  The grip on the javelin remains firm during the entire throwing action. "The recommended withdrawal is for the elbow to reach up and back with hand under javelin" (Paish, 1980:20). "The arms should be fully extended, at shoulder height towards the back, with the shoulders turned in the direction the javelin is going to travel. The start of the throw is the turning of the chest to the front, the trunk, also square to the front, and the back arched slightly. The throwing arm is being whipped forward with the elbow high and the hand trailing" (Hay, 1993:495-501). Speed and strength for the throwing action is developed from strong abdominal and shoulder muscles (Paish, 1980:20).

General adaptations for sitting throwers

Every athlete needs to adapt their throwing action to their own functional abilities. All sitting athletes complete their throw out of a wheelchair or, preferably, a custom made throwing stand. There are certain restrictions and rules established by the International Paralympic Committee that apply to these stands. Generally these chairs/stands are anchored to the ground by cables. Most athletes design their chairs and adopt sitting positions that suit their muscle function, strength, flexibility and personal preference. There are special rules that govern competition as well. Athletes who compete from sitting positions need to remain in contact with the cushion of the chair with at least one part of their buttocks or the upper leg before while in contact with the implement. Athletes who compete in classes F57-F58 must have one foot on the ground inside the circle. Because of above, different athletes may use different putting or throwing techniques.

Chow and Crawford (2000) compare the kinematics of shot putting with the primary classification of the athlete. Because of the rule regulations as well as the primary classification or the persons' disability, the movement at the hips of the sitting athletes during their throwing actions, are minimal. Five linked segments were identified between the hips and shot during the shot put action. The same biomechanical factors that affect the throws of able-bodied athletes applied to the sitting athletes. The speed of release depends largely on the five linked segments that result in the forward thrust of the upper body and the release of the shot put. The five links were:

1. The link from the mid-hips to the mid-shoulders.
2. The link from the mid-shoulder to the throwing shoulder.
3. The link from the shoulder to elbow.
4. The link from the elbow to wrist.
5. The link from the wrist to third knuckle of the hand.

Chow and Mindock (1999) also compared the discus event with athletes' medical classification. The five links used by Chow and Crawford (2000) was used during the biomechanical analysis of the discus throw.

Summary

Every sport has different requirements. It will be of no use to put a long distance runner through the same physical assessment as a rugby player. The assessment protocols needs to meet certain requirements for that specific sport. A test protocol should also respond to the characteristics of the individuals to be tested. A fitness assessment is not just another battery of tests that athletes are expected to perform, but rather a means for collecting information needed to provide answers to specific questions. The questions should relate to the requirements of the sport and, in the case of this study, the functional capabilities of the athletes with disabilities. The answers should lead to adaptations in the training program of the individual and in the long term the benefits should be, improved performance.

A lack of knowledge about fitness testing for the sport-specific needs of individuals with disabilities can have a negative effect on the achievement of maximum sporting potential. Athletics, and more specifically the throwing field events, were a major source of South African medals during the Paralympic Games in Sydney 2000. This study is focussed on developing relevant fitness testing protocols to assist in the development of future athletes in the sitting throwing events. The protocols that were examined as part of this study were designed based on an identification of the key components of physical fitness, an analysis of the functional capabilities of athletes in the different classes within the sitting throwing events, and the specific requirements of the throwing events themselves.

Chapter Three

Methodology

This study examined the validity of a battery of tests of physical fitness variables in relation to athletes' performance in the sitting throwing events. Included in this chapter are the design of the study, the procedures followed and a description of how the data were analysed.

Design

The purpose of the study was to identify which tests of physical fitness are appropriate and valid for athletes with disabilities that competed in throwing field events. This study was based on the model of Strand & Wilson (1993) (see Appendix E) for test construction. Understanding the criteria for good tests was the first step in designing the testing protocol. The three throwing events as well as the movement potential for each class of the athletes, competing in sitting throwing events during the competition, were analysed. A literature review was done and the tests were selected. Procedures to ensure a smooth and scientific testing environment were established. Permission for the testing to be done during the South African Championships for Physical Disabled was asked from the South African Sport Association for the Physical Disabled (SASAPD) and the Western Province Association for Physical Disabled. Data was analysed and the validity of the different tests determined.

Procedures

The procedures followed to answer the research questions of this study are described in the following section.

Review of the criteria for good tests

According to Winnick and Short (2000:21) the following criteria is necessary for selecting tests for athletes with disabilities:

- The test protocol should identify health related concerns for a person with a disability.
- The test protocol reflects a personalised physical fitness profile.
- Some of the tests should be "useful" in more than one disability class.

Other criteria taken into consideration were:

- The test items should be relevant to the specific sport for which testing is done, i.e. the fitness components should be needed in the sport.
- Specificity, i.e. the test items for each component should use movement patterns similar to those needed in the specific sport.

This study was focused exclusively on the determination of test validity and did not address issues of reliability or objectivity. This decision was taken in order to keep the focus on meeting the needs of the different disability classes within the three different throwing events. Also, establishing the reliability and objectivity of test batteries was seen as the next step in research, after a valid test battery is defined.

Analysing the sport and movement potential of each disability class

It is generally accepted by coaches and sport scientists that high levels of performance are dependent upon an identifiable set of basic factors, each one of which carries a relative importance for that activity. The following factors will have an influence on an athletes' ability to reach his/hers full potential:

1. Physical characteristics.
2. Technique.
3. Level of fitness specific to the sport.
4. Psychological factors.
5. An appropriate attitude to training.
6. Opportunity to compete with athletes of a similar or superior level (Bloomfield et al. 1994).

The three factors that were use to design the test batteries examined in this study were the physical characteristics, the technique and the level of fitness specific to the sport.

- **Physical characteristics**

Physical characteristics are closely related to the disabilities of the athletes. Due the influence of the disability on the persons physical capabilities one needs to take it into account when deciding on a test.

According to the International Stokes Mandeville Wheelchair Federation (ISMWF), the objective of the classification system to group together those athletes who have a similar movement potential that makes competition between them approximately equal. The grouping of athletes by movement potential means that they each have an equal chance to make the same movements and therefore have a equal chance to be a winner.

The groups used during this study were those individuals that were competing in field events where they make use of chairs to compete. The two groups of athletes were either from the F30 classes (athletes with cerebral palsy) with the specific classes F31-F34, or the F50 classes (mainly spinal cord injured athletes, although certain individuals with amputations also compete in this class).

The movement potentials associated with the different classes were used to determine which tests the athletes would be able to do. The tests that were selected for use with athletes from the "weaker classes" were used as a basis for all the other classes. As the classes become more mobile, tests were added to the battery. The tests for the F30's and the F50's also differed because of the affect of the cerebral palsy on the movement potential of the F30 athletes.

- **Level of fitness specific to the sport**

The ACSM's guidelines (1995) identified the following physiological components: cardio respiratory endurance, body composition, muscular strength, muscular endurance and flexibility. As a thrower all of the above physiological components do play a role. The most important components for sitting throwers were determined to be muscular strength, muscular endurance and flexibility.

Body composition was measured to see to what extent it contributes to performance of sitting throwers.

- **Biomechanical principles of the sport**

Another factor important to consider when designing a testing protocol is the biomechanical capabilities required to be a good performer in throwing events. The individual who can propel the implement over the longest distance is the best performer. The major biomechanical principles to consider to ensures the best distances are:

- Speed of release.
- Angle of release (which includes height of release).
- Aerodynamic factor (this plays a major role in javelin).

Of the three biomechanical principles only one is influence by physiological factors that can be improve through training. Speed of release is dependant on physiological components. For increased speed one needs strength, power and flexibility. Increased strength will give increased power that is directly related to speed. A greater range of motion (flexibility) through the joint will give a greater distance over which the muscle can contract and build momentum for the release. The angle of release requires technique work. Coaches must teach the individual the optimal angle of release for his/her body height and technique. Aerodynamic factors relate to material physics. Equipment manufacturers play a major role in how this principle impacts performance.

Literature review

A literature review was completed to establish background knowledge about what research had been done on athletes with disabilities and able-bodied athletes in the field of athletics and physical fitness testing. The tests identified in the literature were taken into account when making the test selection for this study.

Test Selection

Fitness tests were identified based on the review of literature that were generally appropriate for athletes in sitting throwing events (see Table 11 and 12). For each test, rationale is provided for its inclusion in the test battery according to the biomechanics of the event or the movement potential of athletes from the different classes.

Table 11. Fitness tests selected from the test categories of anthropometry, flexibility and muscle endurance.

Category of fitness test	Specific test and comments regarding selection
Anthropometry	**Sitting Height:** Height of release plays a major role in distance achieved during performance in able-bodied throwers. Athletes competing in the sitting throwing events rely on the height of their chair (which is specified by rules), their sitting height and their ability to stretch when performing the throw. **Weight:** Greater body mass has a beneficial effect on distance for able-bodied throwers, if the weight is muscle mass. The relationship of body mass/muscle mass for sitting throwers is not known. **Sum of skinfolds:** A big concern for persons with spinal cord injuries is the excessive amount of body fat they accumulate due to their disability and the fact that they are less active. The relationship of this fat mass to the performance of sitting throwers is not known.
Flexibility	**Shoulder internal & external rotation:** The rotator cuff muscles responsible for shoulder internal and external rotation play an important role in the throwing events. Improved flexibility of these muscles will enhance performance. There is a relationship between flexibility and injuries. The distance for contraction of the muscles increases with improved flexibility, which results in greater strength and better performance. **Shoulder mobility:** This is a more dynamic test for shoulder flexibility. It includes shoulder actions like shoulder flexion and abduction, which are not measured by shoulder internal and external rotation tests Improved flexibility of these muscles will enhance performance and reduce injuries. The distance for contraction of the muscles increases with improved flexibility, which results in greater strength and better performance.
Muscle endurance	**Dips:** If an athlete competes from a sitting position, he/she is sometimes required to take six throws consecutively. This means that the muscle endurance of the triceps muscle group is important. The F34, and the F55-F58 athletes did dips. The F33 athletes were excluded from the test because they are hemiplegic. The F52-F54 athletes have weak (if any) abdominal muscle control and are excluded. **Sorenson back extension test:** The F55-F58 athletes performed this test. The relationships between endurance of the back muscles and throwing performance are unknown. The same reasons as for dips account for the other groups for not doing this test.

Table 12. Fitness tests selected from the test categories of strength and power.

Category of fitness test	Specific test and comments regarding selection
Strength	**Bench press:** The bench press is a well-accepted predictor of upper body strength. The main muscle groups involved in the bench press action are the triceps muscle group and the pectoralis muscles. The F33 athletes do not do the bench press because they are hemiplegic which can lead to problems when performing the test. The F34 athletes do not do the bench press because of the coordination problems. All of the other classes did the bench press. **Grip strength:** Grip strength has been used to determine upper body strength in able-bodied athletes. If this is true for sitting throwers, then it might not be necessary to require the bench press test to measure upper body strength. All the classes did the test. **Shoulder abduction:** This test is very important for the F51-F52 athletes. One of their main muscles groups is the shoulder muscle group responsible for shoulder abduction. Also, the relationship between the strength of the shoulder muscles responsible for shoulder abduction and performance in the throwing events is not known. If the relationship is significant, focussing on strengthening these muscle groups will improve performance. All the classes performed this test. **Shoulder flexion:** This test is very important for the F51-F52 athletes. One of their main muscles groups is the shoulder muscle group responsible for shoulder flexion. Also, the relationship between the strength of the shoulder muscles responsible for shoulder flexion and performance in the throwing events is not known. If the relationship is significant, focussing on strengthening these muscle groups will improve performance. Although it is most important for the F51-F52 classes all the classes performed this test. **Abdominal strength:** The only groups performing this test are the F55-F58 athletes athletes. According to classification, these are the classes with functional abdominal muscles.
Power	**Basketball Chest Pass:** The muscles involved in doing the three throwing events and the muscles that are used to do the basketball chest pass are similar. All the classes performed this test. **Basketball Overhead Pass:** With the basketball chest pass, the triceps are the main movers. With the overhead pass the wrist flexors and shoulder extension have a greater influence on performance. All the classes performed this test.

Based upon the options available in each category of fitness, a specific test battery was designed for each of the disability categories. It was decided not to specify the throwing event that corresponded to each test, because the data analysis of correlations between fitness test performance and actual performance in competition should identify the best battery per event. A table has been created for each class that describes the movement potential of the athletes in that class and their rating on the R-H system. As a reminder, the R-H system rates the mobility of an athlete in the F51 to F58 classes from zero to five according to the following criteria:

Table: 13 R-H-system

SCORE	EXPLANATION
0-1	No movement possible.
2-3	Some movement possible, but only against gravity as resistance.
4-5	Movement possible, with external resistance.

Each table also describes the actions that athletes in the class typically can perform, practical comments/notes that can guide test administrators, and an identification of the tests (See Tables 14 to 22). For the athletes with cerebral palsy, F31-34, the spasticity limitations are also noted.

Table 14. Fitness test batteries for athletes in the F51 and F52 classes.

Class	Movement Potential	Oxford Scale	Actions	Notes	Tests
F51	Muscles involving shoulder movement	4	Flex/Ext, Abd/Add, Shrugs, Int/Ext rot,	Can't grip anything need strapping.	**Anthropometry**: Sitting height Weight Sum of skinfolds (biceps, triceps, subscapula) **Flexibility** Shoulder internal/external rotation Shoulder mobility **Strength** Shoulder abduction Shoulder flexion
	Elbow Flexors	3	Forearm Flexion		
	Elbow Extensors	1-3	-		
	Wrist Dorsiflexors	3	Wrist Flexion		
	Wrist Palmar Flexors	0	-		
	Abdominal muscles	0	-		
F52	Muscles involving shoulder movement	4	See F51	May be or may not be able to grip, strapping may be a necessity.	**Anthropometry** Sitting height Weight Sum of three skinfolds (biceps, triceps, subscapula) **Flexibility** Shoulder internal & external rotation. Shoulder mobility. **Strength** Bench press Shoulder flexion Shoulder abduction **Power** Basketball chest pass Basketball overhead pass
	Elbow Flexors	4	See F51		
	Elbow Extensors	4	Forearm Extension		
	Wrist Dorsiflexors	4	Wrist Dorsiflexion		
	Wrist Palmar Flexors	4	Wrist Palmar Flexion		
	Finger Flexors/Extensors	<3	-		
	Abdominal muscles	0	-		

Table 15. Fitness test batteries for athletes in the F53 and F54 classes.

<table>
<tr><th>Class</th><th>Movement Potential</th><th>Oxford Scale</th><th>Actions</th><th>Notes</th><th>Tests</th></tr>
<tr><td rowspan="8">F53</td><td>Muscles involving shoulder movement</td><td>5</td><td>F52</td><td rowspan="8">Can close hand but can use thumb.</td><td rowspan="8">Anthropometry
Sitting height
Weight
Sum of three skinfolds (biceps, triceps, subscapula)
Flexibility
Shoulder internal & external rotation.
Shoulder mobility.
Strength
Bench press
Shoulder flexion
Shoulder abduction
Grip strength
Power
Basketball chest pass
Basketball overhead pass</td></tr>
<tr><td>Elbow Flexors</td><td>5</td><td>F52</td></tr>
<tr><td>Elbow Extensors</td><td>5</td><td>F52</td></tr>
<tr><td>Wrist Dorsiflexors</td><td>5</td><td>F52</td></tr>
<tr><td>Wrist Palmar Flexors</td><td>5</td><td>F52</td></tr>
<tr><td>Finger Flexors/Extensors</td><td>4-5</td><td>Finger Flex/Ext</td></tr>
<tr><td>Intrinsic hand muscles</td><td>3</td><td>Can close hand</td></tr>
<tr><td>Abdominal muscles</td><td>0</td><td>-</td></tr>
<tr><td rowspan="2">F54</td><td>Upper limb muscles</td><td>5</td><td>F53
&
full use of intrinsic hand muscles</td><td rowspan="2">Full upper limb, no trunk movements, will need strapping.</td><td rowspan="2">Anthropometry
Sitting height
Weight
Sum of three skinfolds (biceps, triceps, subscapula)
Flexibility
Shoulder internal & external rotation.
Shoulder mobility.
Strength
Bench press
Shoulder flexion
Shoulder abduction
Grip strength
Power
Basketball chest pass
Basketball overhead pass</td></tr>
<tr><td>Abdominal muscles</td><td>0</td><td>-</td></tr>
</table>

Table 16. Fitness test battery for athletes in the F55 class.

<table>
<tr><th>Class</th><th>Movement Potential</th><th>Oxford Scale</th><th>Actions</th><th>Notes</th><th>Tests</th></tr>
<tr><td rowspan="6">F55</td><td>Upper limb muscles</td><td>5</td><td>F54</td><td rowspan="6">No legs; No hip flexion; Trunk rotation may be weak.</td><td rowspan="6">Anthropometry
Sitting height
Weight
Sum of three skinfolds (biceps, triceps, subscapula)
Flexibility
Shoulder internal & external rotation.
Shoulder mobility.
Strength
Bench press
Shoulder flexion
Shoulder abduction
Grip strength
Abdominal strength (7 Stage abdominal test)
Power
Basketball chest pass
Basketball overhead pass
Muscle Endurance:
Dips (to exhaustion)</td></tr>
<tr><td>Abdominal muscles</td><td>4</td><td>Trunk Flexion</td></tr>
<tr><td>Back Extension muscles</td><td>4</td><td>Back Extension</td></tr>
<tr><td>Trunk Rotators</td><td>3</td><td>Trunk Rotation</td></tr>
<tr><td>Hip Flexors</td><td>1</td><td>-</td></tr>
<tr><td>Hip Adductors</td><td>0</td><td>-</td></tr>
</table>

Table 17. Fitness test battery for athletes in the F56 class.

<table>
<tr><th>Class</th><th>Movement Potential</th><th>Oxford Scale</th><th>Actions</th><th>Notes</th><th>Tests</th></tr>
<tr><td rowspan="7">F56</td><td>Upper limb muscles</td><td>5</td><td>Full upper extremity</td><td rowspan="7">No hip abduction and no hip extension.
No ankle movement.</td><td rowspan="7">Anthropometry
Sitting height
Weight
Sum of three skinfolds (biceps, triceps, subscapula)
Flexibility
Shoulder internal & external rotation
Shoulder mobility
Strength
Bench press
Shoulder flexion
Shoulder abduction
Grip strength
Abdominal strength
Power:
Basketball chest pass
Basketball overhead pass
Muscle Endurance:
Dips (to exhaustion)
Sorenson back extension</td></tr>
<tr><td>Abdominal Flexors</td><td>5</td><td rowspan="3">Full Trunk movements</td></tr>
<tr><td>Back Extension muscles</td><td>5</td></tr>
<tr><td>Trunk Rotators</td><td>4</td></tr>
<tr><td>Hip Flexors</td><td>4</td><td>Hip Flexion</td></tr>
<tr><td>Hip Adductors</td><td>3</td><td>Slight Hip Adduction</td></tr>
<tr><td>Knee Extensors / Knee Flexors</td><td>2</td><td>May have slight quad and hamstring functions.</td></tr>
</table>

Table 18. Fitness test battery for athletes in the F57 class.

Class	Movement Potential	Oxford Scale	Actions	Notes	Tests
F57	Upper limb muscles	5	Full Upper extremity		**Anthropometry** Sitting height Weight Sum of three skinfolds (biceps, triceps, subscapula) **Flexibility** Shoulder internal & external rotation Shoulder mobility **Strength** Bench Press Shoulder flexion Shoulder abduction Grip strength Abdominal strength **Power** Basketball chest pass Basketball overhead pass **Muscle Endurance** Dips (to exhaustion) Sorenson back extension
	Abdominal Flexors	5	Full trunk		
	Back extension muscles	5	Full trunk		
	Hip Abductors (one side)	5	Hip Abduction		
	Hip Extensors (one side)	4	Hip Extension		
	Knee Extensors	4 –5	Knees Extension		
	Ankle Plantar flexors (one side)	3	-		

Table 19 . Fitness test battery for athletes in the F58 class.

Class	Movement Potential	Oxford Scale	Actions	Notes	Tests
F58	Upper limb muscles	5	Full	Choose to sit and compete, includes amputees – Single above knee, bilateral below knee who choose to sit.	**Anthropometry** Sitting height Weight Sum of three skinfolds (biceps, triceps, subscapula) **Flexibility** Shoulder internal & external rotation Shoulder mobility **Strength** Bench Press Shoulder flexion Shoulder abduction Grip strength Abdominal strength (7 Stage abdominal test) **Power** Basketball chest pass Basketball overhead pass **Muscle Endurance** Dips (to exhaustion) Sorenson back extension.
	Trunk muscles	5	Full		
	Lower limb muscles	3 –4	Ankles not good		

Table 20. Fitness test batteries for athletes in the F31 and F32 classes.

Class	Movement Potential	Actions	Spasticity/ Limitations	Tests
F31 (Quadri-plegia/ Tetra-plegia)	Poor functional strength and control. Poor ROM. All extremities involved, including trunk.	Poor follow through. Opposition of thumb and finger may be possible- Grip therefore possible.	Severe athetoid with or without spasticity. With or without athetosis. Gr4 – 3+ spasticity. Electric wheelchair	**Anthropometry** Sitting height Weight Sum of skinfolds (biceps, triceps, subcapula) **Flexibility** Shoulder internal & external rotation Shoulder mobility **Strength** Shoulder Abduction Shoulder Flexion
F32 (Quadri-plegia/ Tetra-plegia)	**Trunk** Static movements- FAIR Dynamic-POOR **Hand** Severe to moderate **Lower Limbs** Might be able to walk	Poor grasp and release. **Active ROM** Moderate to severely impaired. **Lower limbs:** Kick/thrust with legs **Upper Limbs** Limited control over movements	Severe athetoid or tetraplegic. More function in less affected side. Gr3+ - Gr3 severe to moderate involvement. With or without athetosis. Able to propel wheelchair	**Anthropometry** Sitting height Weight Sum of skinfolds (biceps, triceps, subcapula) **Flexibility** Shoulder internal & external rotation Shoulder mobility **Strength** Shoulder Abduction Shoulder Flexion **Power** Basketball overhead pass Basketball chest pass

Table 21. Fitness test battery for athletes in the F33 class.

Class	Movement Potential	Actions	Spasticity/ limitations	Tests
F33 **(Quadriplegia/ Tetraplegia** **Severe hemiplegia**	**Upper limbs** Full functional strength in dominant upper extremity. **Lower limbs** May be able to walk with assistance. **Trunk** Fair; forward movement limited	**Lower** Kick or thrust. **Trunk** Throwing action not using trunk but arm. Rotation limited Spasticity: Gr3+-2 **Upper limbs** Limitation in extension and follow through. **Hand** Grasp and release slow. Cylindrical and spherical grasp.	**Lower Limbs** Spasticity: Gr4-3 **Upper Limbs** Moderate limitations Gr3 –2 in dominant. Wheelchair, but may be able to walk with assistance	**Anthropometry** Sitting height Weight Sum of skinfolds (biceps, triceps, subscapula) **Flexibility** Shoulder internal & external rotation Shoulder mobility **Strength** Shoulder abduction Shoulder flexion Grip strength Abdominal strength **Power** Basketball overhead pass Basketball chest pass

Table 22. Fitness test battery for athletes in the F34 class.

Class	Movement Potential	Actions	Spasticity/ limitations	Tests
F34 (Diplegia)	Good functional strength with minimal limitations or control problems in the upper limbs and trunk	**Lower Limbs** Not functional over long distances **Trunk** Disturbance in trunk movement when force or speed is required. **Upper limbs** Normal follow through, minimal ROM limitations. Normal functional strength **Hand** Cylindrical / spherical opposition.	**Lower Limbs** Gr4 – 3 in both legs. **Trunk** Minimal limitations – Gr2-1 With fatigue – increase in spasticity. **Hand** Limitation during rapid, fine motor tasks. Wheelchair for sports	**Anthropometry** Sitting height Weight Sum of skinfolds (biceps, triceps, subcapula) **Flexibility** Shoulder internal & external rotation Shoulder mobility **Strength** Shoulder abduction Shoulder flexion Grip strength Abdominal strength **Power** Basketball overhead pass Basketball chest pass **Muscle Endurance** Dips (to exhaustion)

Establish Procedures

Baumgartner and Jackson (1975) identified planning as the key to good testing. According to them there are 3 steps to be carried out for the testing to be successful: (1) pretest planning, (2) administration of the test, (3) post-test procedures. Heyward (1998) supported the importance of planning. These procedures were followed in this study.

1. Pre-test planning: This is undertaken before administering the test. Factors like: knowing the test, developing the testing procedure and directions, preparing the athletes, planning warm-up and number of trials, securing equipment and boundary lines, preparing the score sheets and estimate time needed for testing (Baumgartner and Jackson, 1975). Heyward (1998) noted the importance of instructing the athlete on what to eat before testing, what to wear to testing and what to do the day before testing. Gore (2000) recommended that checklists of the equipment needed and checklists covering the general considerations for the laboratory to be prepared. Further recommendations are questionnaires regarding the athletes diet, medical examination forms, health questionnaires, informed consent form and information regarding the physiological requirements of the test from the athlete.

2. Administration of the test: Explanation of the test and importance of the test for the athlete are described to the athlete, motivation during the test should be standardize so that each athlete gets the same amount of encouragement. The safety of the participant should be ensured at all times (Baumgartner & Jackson, 1975). Knowledge about the test and the mastery of the standardized testing procedures are directly related to the expertise and technical skills of the tester (Heyward, 1998).

3. Post-test procedures: Interpretation of the test results and comparing the athlete to normative data (Heyward, 1998; Baumgartner and Jackson, 1975).

Pre-event administration

Permission for this study was given by the South African Sports Association for Physically Disabled and the Western Province Association for Physical Disabled. Testing was completed during the South African Championships held in April 2001 in Stellenbosch.

Selection of subjects

On the first Saturday of the Championships, a meeting was held for all team managers. At this meeting the motivation and general testing procedures for the study were explained to the team managers and their cooperation in recruiting volunteers from their teams were requested. It was promised that all athletes who participated in the study would receive a physical fitness report on the last day of the Championships. Each team manager received a schedule for testing and was asked again to encourage his/her team members to participate. The days selected as testing days were scheduled to overcome transport problems for the athletes. Three days of testing were scheduled. On the Tuesday of the Championships, all the athletes who volunteered completed their anthropometry, flexibility and power evaluations. No strength testing was done because some athletes had not yet competed in all their events. Thursday and Friday was scheduled for the strength testing.

The testing area was set up in the indoor tennis court next to the athletic stadium. The athlete or his/her guardian signed consent forms when the athlete reported for testing on the first day.

Recruiting test personnel

Testers were recruited at the Department of Sport Science, University of Stellenbosch. The volunteers were either post graduate students in Sport Science or third year Sport Science students specialising in adapted physical activities. The testers were trained during two sessions to acquaint them with the testing procedures and what to expect.

The day of the testing

Before any athlete could take part in the testing procedure a consent form (Appendix D) was signed. For those athletes who were too young to sign for themselves, team managers signed as guardians. The testing procedure, the reason for the testing as well as the testing sequence was explained to the athletes. The importance of coming back for the second day of testing and of giving their best was highlighted.

Tests of day one:

- Height.
- Weight.
- Skinfolds.
- Shoulder mobility.
- Shoulder internal and external rotation.
- Basketball chest pass.
- Basketball overhead pass.

Tests of day two:

- Shoulder flexion/extension.
- Shoulder abduction/adduction.
- Bench press.
- Abdominal strength.
- Dips.
- Sorenson test.

Data analysis

The data were put into a database, where reports for the individual athletes were generated. For the purpose of analysis, data from the following classes were combined:

- The F33 and F34 classes were combined.
  It is known that the F33 class is hemiplegic and the F34 class diplegic with basic full upper body function. Their functional ability does differ, but the limitation that not enough athletes of each of these classes participate in the testing was considered. These two classes were combined during the Sydney Paralympic Games.

- F52 –F54 were combined.
  These classes were combined groups because these athletes do not have any active abdominal muscles.

- F55-F58 classes were group together.
  F55-F58 classes do have active abdominal muscles. F56-F58 athletes did only one more test than the F55 class.

Descriptive analysis and a Pearson correlation were done with the data to correlate the athletes' performances on the different tests with the athletes' performances during actual competition. A multiple regression analysis was done with the F55-F58 shot put and discus group. These were the only two events with enough participants to allow a multiple regression analysis.

Summary

The formulation of test batteries for the different disability classes in these sitting throwing events was completed in a systematic manner. Data were gathered on both the fitness tests and the performance in competition within a four-day period at the National Championships for Physically Disabled. The results of the statistical treatment of the data are presented in the next chapter.

Chapter Four

Results and Discussion

Strand and Wilson (1993) considered the determination of test validity to be the first step in the design of effective methods of evaluation. The main purpose of this study was to determine validity of the tests with a test battery, selected specifically for athletes competing in sitting throwing events. The importance of scientifically-validated methods of testing is supported by Bloomfield et al. (1994) that many of the improvements in sport performance standards the past 20 years could be accredited to the contribution of sport science and medicine. They further noted that performance can be improved if physical strengths and weaknesses are identified and addressed during training.

Data for this study was collected during the South African National Championships for Physical Disabled. Seventy-five athletes (N = 75) completed the test batteries developed specifically for their sport classification. Because of the small number of athletes in each class, and because there were some logical bases for combining classes, the results of the subjects were processed according to three groups:

- F33-F34 (n = 14).
- F52-F54 (n = 16).
- F55-F58 (n = 45).

Descriptive statistics were calculated for the athletes in these groups (see Appendix C). In order to determine the validity of each test item, Pearson product-moment correlations were computed between each test performance and performance in each of the three throwing events. Because there were a sufficient number of participants in the F55-F58 shot put and discuss events, it was possible to complete a multiple regression analysis of the data to identify which fitness tests were the best predictor of performance in actual competition. It was also possible to generate simple linear regression equations that can be used to predict the performance in actual competition according to scores on certain fitness tests.

Research Question One

What are the test items in a valid physical fitness test battery for athletes with physical disabilities who compete in the sitting shot put event?

Valid tests for Shot put F33-F34

- ✓ Basketball chest pass.
- ✓ Preferred grip strength.

Valid tests for Shot put F52-F54:

- ✓ Sitting height.
- ✓ Estimated 1 repetition maximum bench press.
- ✓ Non-preferred shoulder flexion.
- ✓ Preferred shoulder flexion.
- ✓ Non-preferred shoulder abduction.
- ✓ Preferred shoulder abduction.
- ✓ Basketball chest pass.
- ✓ Basketball overhead pass.
- ✓ Non-preferred grip strength.
- ✓ Preferred grip strength.

Valid tests for Shot put F55-F58:

- ✓ Sitting height.
- ✓ Estimated 1 repetition maximum bench press.
- ✓ Non-preferred shoulder flexion.
- ✓ Preferred shoulder flexion.
- ✓ Non-preferred shoulder abduction.
- ✓ Preferred shoulder abduction.
- ✓ Basketball chest pass.
- ✓ Basketball overhead pass.
- ✓ Non-preferred grip strength.
- ✓ Preferred grip strength.

Table 23 presents the correlation coefficients between test results and shot put performance.

Table 23. Correlations between shot put performance and test results.

Test	F33-F34	F52-F54	F55-F58
	Shot put	Shot put	Shot put
Sitting height	0.442	0.819*	0.548*
Weight	0.065	0.718*	0.229
Sum of skinfolds	0.499	0.177	0.277
Estimated 1 repetition maximum bench press	•	0.857*	0.632*
Non-preferred shoulder flexion	0.595	0.937*	0.596*
Preferred shoulder flexion	0.476	0.947*	0.662*
Non-preferred shoulder abduction	0.488	0.926*	0.666*
Preferred shoulder abduction	0.538	0.942*	0.586*
Non-preferred grip strength	0.510	0.940*	0.741*
Preferred grip strength	0.664*	0.850*	0.818*
Basketball chest pass	0.638*	0.857*	0.664*
Basketball overhead pass	0.543	0.953*	0.653*
Non-preferred shoulder internal rotation	0.088	0.298	0.219
Preferred shoulder internal rotation	0.034	0.394	0.070
Non-preferred shoulder external rotation	0.270	0.472	0.279
Preferred shoulder external rotation	0.266	0.228	0.263
Non-preferred shoulder mobility	0.240	0.335	0.135
Preferred shoulder mobility	0.179	0.515	0.048
Sorenson test	•	•	0.137
Abdominal strength	•	•	0.029
Dips	•	•	0.377

$p<0.05$

• did not do the test

Comments on each test

Sitting height

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	Yes

Classes F55-F58 and F52-F54 performance in shot put did have a significant correlation with sitting height. Because there are restrictions on the chairs used in competition, sitting height may play a role in shot put. Due to the relative short distances the shot is put, any advantage one can get by a higher point of release, e.g sitting height, has the potential to increase performance distance.

The reason for no correlation between the F33-F34 athletes' performance in shot put and their sitting height may be because athletes with cerebral palsy may rely more on coordination during the action than the height of release. The athlete with the greatest sitting height also might not be the athlete who can coordinate his/her actions to stretch to the fullest when throwing. It must also be noted that there is greater heterogeneity within the F33-F34 group, which will influence statistical treatment of the data.

Weight

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	No

The shot put performance of the F52-F54 athletes did have a significant correlation with their weight.

Excessive weight will not be as detrimental for performance in sitting events as in standing throwing events. The athlete does not need to carry his/her weight, due to the fact that he/she competes sitting. This means that performance will not be influenced as much by weight in the sitting classes since there is limited weight transfer during the throw.

Sum of skinfolds

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found between sum of skinfolds and throwing performance. Because these athletes all compete from a sitting position, an excessive amount of body fat will not hinder their performance as much as it would hinder the performance of a standing or able-bodied athlete. The standard deviation for all three groups varies from a minimum of 13 to a maximum of 24, which indicates that the athletes' sum of skinfolds varied quite a bit.

Estimated 1 repetition maximum bench press

Classes	Significant correlation?
F33-34	Does not apply
F52-54	Yes
F55-58	Yes

No bench press test was done with the F33-F34 athletes. A significant correlation was found for F52-F54 and F55-F58 shot put performance and estimated 1 repetition maximum bench press. The estimated 1 repetition maximum bench press is a good simulator of the shot put action and the significant correlation can be due to the fact the muscles used for the test are also used for shot put performance.

Non-preferred shoulder flexion

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	Yes

F52-F54 and F55-F58 athletes' shot put performances do have significant correlations with non-preferred shoulder flexion. The non-preferred side of the F52-F54 and F55-F58 athletes appeared to be developed in a similar/balanced manner to their preferred side. In most instances, if there is a significant correlation with the preferred side, the correlation will be significant for the non-preferred side will as well. Both shoulders are used when propelling a wheelchair and this develops the non-preferred side as much as the preferred side. There are some athletes where this will differ, for instance athletes who had polio or the les autres group, therefore it is not a generalisation, but rather a tendency that can be expected.

The reason for no significant correlation between F33-F34 athletes' shot put performance and their non-preferred shoulder flexion could be that it is the non-preferred arm that is affected by cerebral palsy in F33-F34 classes. However, the degree to which the non-preferred arm is affected differs quite substantially.

Preferred shoulder flexion

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	Yes

The shot put performances of F52-F54 and F55-F58 athletes did have significant correlations with preferred shoulder flexion. This is not surprising since this range of motion is critical to throwing action.

The lack of a significant correlation for the F33-F34 athletes could be due to the coordination problem of athletes in these classes. The F33 athletes are more severely affected in the arms and shoulders than the F34 athletes.

Non-preferred shoulder abduction

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	Yes

F52-F54 and F55-F58 athletes' shot put performances did have a significant correlation with non-preferred shoulder abduction. The non-preferred side of the F52-F54 and F55-F58 athletes are developed in a manner similar to their preferred side. Both shoulders are used when propelling a wheelchair and this develops the non-preferred side as much as the preferred side. There are some athletes where this will differ, for instance athletes who had polio or the les autres group, therefore this is not a generalisation, but it is a tendency that can be expected.

The lack of a significant correlation for F33-F34 athletes' shot put performance with their non-preferred shoulder abduction could be due to the non-preferred arm being affected by cerebral palsy. The degree to which the arm is affected differs quite substantially between the F33 and F34 athletes.

Preferred shoulder abduction

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	Yes

F52-F54 and F55-F58 athlete's shot put performances did have significant correlations with preferred shoulder flexion. A significant correlation means that shoulder abduction muscles play a role in shot put performance.

No significant correlation between preferred shoulder abduction for the F33-F34 athletes could be due to the coordination problem of these athletes. The F33 athletes are more severely affected in the arms and shoulders than the F34 athletes.

Non-preferred grip strength

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	Yes

F52-F54 and F55-F58 athletes' shot put performances correlated significantly with their non-preferred grip strength. The preferred and non-preferred sides of the F52-F54 and the F55-F58 classes should be developed similarly. Since grip strength is a measure of upper body strength, it could be expected that a significant correlation would be found between grip strength and performance in the throwing events.

The F33-F34 class do have a significant difference between the preferred and non-preferred side. The lack of a significant correlation between performance in shot put for F33-F34 athletes and their non-preferred grip strength is an indication of the imbalance between their non-preferred and preferred sides, which is evident in many of the bi-lateral tests.

Preferred grip strength

Classes	Significant correlation?
F33-34	Yes
F52-54	Yes
F55-58	Yes

F52-F54, F55-F58 and F33-F34 athletes' shot put performances correlated significantly with the test scores.

Grip strength in able-boded athletes is a good indicator of upper body strength. The significant correlation with the preferred grip strength of athletes with disability in the shot put indicates the relationship between grip strength, upper body strength and shot put performance. Minimal coordination is needed to perform this test. This makes it a viable measure of the strength of athletes with cerebral palsy.

Basketball chest pass

Classes	Significant correlation?
F33-34	Yes
F52-54	Yes
F55-58	Yes

F52-F54, F55-F58 and F33-F34 athletes' shot put performances correlate significant with the results of the basketball chest pass. The basketball chest pass is regarded as a good indicator of upper body power for an athlete. The significant correlations are an indication that this test is a valid measure of the upper body power needed by sitting throwers in the shot put.

Basketball overhead pass

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	Yes

F52-F54 and F55-F58 athletes' shot put performances correlated significantly with their scores on the basketball overhead pass test. The basketball overhead pass is also a good indicator of upper body power. The F52-F54 and F55-F58 athletes have good shoulder mobility and control of the shoulder muscles therefore a significant correlation could be expected.

This test uses slightly different muscles than the chest pass and is more difficult to control. For an F33-F34 athlete, the action is slightly more difficult due to coordination problems and problems with using the affected side properly. Some athletes may be able to use the affected side while others might find it difficult. This can lead to inconsistency in performances, which could account for the lack of significant correlation between this test and their shot put performance.

Non-preferred shoulder internal rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. Large standard deviations were found in the data for all classes. This shows a great variety in flexibility among sitting throwers. This does not mean that flexibility is not important, but that the role it plays in the sitting shot put performance is not clear. The loss of mobility among athletes in the F33-F34 class non-preferred side, due to cerebral palsy, will contribute to the failure to find significant correlations between the scores on this test and their throwing performance.

Preferred shoulder internal rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. Large standard deviations were found in the data for all classes. This shows a great variety in flexibility among sitting throwers. This does not mean that flexibility is not important, but that the role it plays in the sitting shot put performance is not clear.

Non-preferred shoulder external rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. Large standard deviations were found in the data for all classes. This shows a great variety in flexibility among sitting throwers. This does not mean that flexibility is not important, but that the role it plays in the sitting shot put performance is not clear. The loss of mobility among athletes in the F33-F34 class non-preferred side, due to cerebral palsy, will contribute to the failure to find significant correlations between the scores on this test and their throwing performance.

Preferred shoulder external rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. Large standard deviations were found in the data for all classes. This shows a great variety in flexibility among sitting throwers. This does not mean that flexibility is not important, but that the role it plays in the sitting shot put performance is not clear.

Non-preferred shoulder mobility

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. Large standard deviations were found in the data for all classes. This shows a great variety in flexibility among sitting throwers. . This does not mean that flexibility is not important, but that the role it plays in the sitting shot put performance is not clear. The loss of mobility among athletes in the F33-F34 class non-preferred side, due to cerebral palsy, will contribute to the failure to find significant correlations between the scores on this test and their throwing performance.

Preferred Shoulder Mobility

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. Large standard deviations were found in the data for all classes. This shows a great variety in flexibility among sitting throwers. This does not mean that flexibility is not important, but that the role it plays in the sitting shot put performance is not clear.

Sorenson test

Classes	Significant correlation?
F33-34	Does not apply
F52-54	Does not apply
F55-58	No

No significant correlations were found between scores on the Sorenson test and performance in the shot put for athletes in the F55-F58 class, the only group to do the Sorenson test. The range of scores was from 3 seconds to 90 seconds with a standard deviation of 35. This is an indication of the heterogeneity of the group.

Abdominal strength

Classes	Significant correlation?
F33-34	Does not apply
F52-54	Does not apply
F55-58	No

No significant correlation for athletes in the F55-F58 class, the only group to do the abdominal strength test. The use of the abdominal muscles may not always be optimised during throwing. The use of strapping may lead to under-training of the abdominal muscles. Some athletes may not even be aware of the functional ability of their abdominal muscles. Because throwing is often associated with proper use of the abdominal muscles, this is an area that warrants further research.

Dips

Classes	Significant correlation?
F33-34	Does not apply
F52-54	Does not apply
F55-58	No

No significant correlations were found for the athletes in the F55-F58 class, the only group to perform this test. The range of dips was from 7 to 99 with a standard deviation of 21.5. This is an indication of the variance with the group, which makes achievement of a significant correlation extraordinarily difficult. Muscle endurance also may be under-estimated in the throwing events because the throwing events are often thought of as strength events and not as endurance events.

Research Question Two

What are the test items in a valid physical fitness test battery for athletes with physical disabilities who compete in the sitting discus event?

Valid tests for Discus F33-F34

- ✓ Sum of skinfolds.
- ✓ Basketball chest pass.
- ✓ Basketball overhead pass.
- ✓ Preferred grip strength.

Valid tests for Discus F52-F54

- ✓ Basketball chest pass.
- ✓ Basketball overhead pass.

Valid tests for Discus F55-F58

- ✓ Sitting height.
- ✓ Estimated 1 repetition maximum bench press.
- ✓ Non-preferred shoulder flexion.
- ✓ Preferred shoulder flexion.
- ✓ Non-preferred shoulder abduction.
- ✓ Preferred shoulder abduction.
- ✓ Basketball chest pass.
- ✓ Basketball overhead pass.
- ✓ Non-preferred grip strength.
- ✓ Preferred grip strength.

Table 24 presents the correlation coefficients between test results and discus performance.

Table 24. Correlations between discus performance and test results.

Test	F33-F34	F52-F54	F55-F58
	Discus	Discus	Discus
Sitting height	0.597	0.393	0.637*
Weight	0.408	0.016	0.305
Sum of skinfolds	0.840*	0.246	0.351
Estimated 1 repetition maximum bench press	•	0.347	0.613*
Non-preferred shoulder flexion	0.450	0.114	0.554*
Preferred shoulder flexion	0.454	0.134	0.557*
Non-preferred shoulder abduction	0.355	0.529	0.574*
Preferred shoulder abduction	0.289	0.537	0.641*
Non-preferred grip strength	0.663	0.342	0.579*
Preferred grip strength	0.699*	0.515	0.608*
Basketball chest pass	0.857*	0.670*	0.775*
Basketball overhead pass	0.854*	0.843*	0.797*
Non-preferred shoulder internal rotation	0.000	0.341	0.138
Preferred shoulder internal rotation	0.100	0.036	0.203
Non-preferred shoulder external rotation	0.140	0.277	0.229
Preferred shoulder external rotation	0.357	0.417	0.083
Non-preferred shoulder mobility	0.382	0.303	0.037
Preferred shoulder mobility	0.246	0.282	0.078
Sorenson test	•	•	0.250
Abdominal strength	•	•	0.167
Dips	•	•	0.269

* = $p<0.05$

• did not do the test

Comments on each test

Sitting height

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	Yes

There was a significant correlation between the F55-F58 athletes' performances in the discus and their sitting height. It is possible that sitting height does not play as an important role in the discus as it does in the shot put. Because distances acquired in the discus events are generally greater than in shot put, the advantage one gets by a higher releasing sitting height may not be quite as critical. For the F55-F58 classes, technique gets more important and therefore it might be possible that the contribution made to point of release by sitting height is important.

Finding no significant correlation between the F33-F34 athletes' discus performance and their sitting height may be because athletes with cerebral palsy rely more on their coordination to achieve distance than they do a full body stretch to release.

Weight

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlation was found. Weight is not as important, and excessive weight is not as detrimental, for performance in sitting events as it is in the standing throwing events. Athletes don't carry their weight because they compete from a sitting position.

Comments on each test

Sitting height

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	Yes

There was a significant correlation between the F55-F58 athletes' performances in the discus and their sitting height. It is possible that sitting height does not play as an important role in the discus as it does in the shot put. Because distances acquired in the discus events are generally greater than in shot put, the advantage one gets by a higher releasing sitting height may not be quite as critical. For the F55-F58 classes, technique gets more important and therefore it might be possible that the contribution made to point of release by sitting height is important.

Finding no significant correlation between the F33-F34 athletes' discus performance and their sitting height may be because athletes with cerebral palsy rely more on their coordination to achieve distance than they do a full body stretch to release.

Weight

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlation was found. Weight is not as important, and excessive weight is not as detrimental, for performance in sitting events as it is in the standing throwing events. Athletes don't carry their weight because they compete from a sitting position.

Sum of skinfolds

Classes	Significant correlation?
F33-34	Yes
F52-54	No
F55-58	No

The discus performance of F33-F34 athletes' correlates significantly with their sum of skinfolds. The body weight in fat that is not used during the throw appears to have no significant impact on throwing distance. It is possible that the F33-34 athletes with cerebral palsy have learned to "get their weight" into their throws, which is why a significant correlations was found for them.

Estimated 1 repetition maximum bench press

Classes	Significant correlation?
F33-34	Does not apply
F52-54	No
F55-58	Yes

No bench press was done with the athletes in the F33-F34 classes. A significant correlation was found between the discus performance of the F55-F58 athletes and their estimated 1 repetition maximum bench press. This significant correlation could be because of their use of technique. More strength is necessary to perform better in the higher classes because of increased use of the body's muscles and the potential of increased muscle function to support better technique. In the lower classes, an athlete might win by either being a very strong athlete or technically very correct. In the higher classes, athletes need to have both strength and technique. When athletes have equally good technique, the winner should be the athlete who can generate the most strength and power during the throw.

Non-preferred shoulder flexion

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	Yes

F55-F58 discus performances do have significant correlations with non-preferred shoulder flexion. The reason for a higher significant correlation for the F55-F58 class can be that strength are getting more important as the classes get more use of the body's muscles. The preferred and non-preferred side should be of even strength.

No significant correlation between non-preferred shoulder flexion and the F33-F34 athletes' shot put performance was found. This can be because the arm that is affected by cerebral palsy is the athlete's non-preferred side. The degree to which the arm is affected differs substantially among athletes from these classes.

Preferred shoulder flexion

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	Yes

The discus performance of the F55-F58 athletes' did have a significant correlation with their preferred shoulder flexion. The absence of a significant correlations between shoulder flexion and the discus performance of F52-F54 athletes can be because shoulder flexion does not play a critical role in discus throwing for this athletes in this class.

No significant correlation was found with the discus performance of the F33-F34 athletes.

Non-preferred shoulder abduction

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	Yes

There was a significant correlation between the F55-F58 athletes' discus performances and their non-preferred shoulder abduction. The reason for this significant correlation may be that the activities they do to develop strength for their preferred shoulder will also develop their non-preferred shoulder.

No significant correlation for F33-F34 shot put performance can be due to the fact that the arm that is affected by cerebral palsy in F33-F34 is the athlete's non-preferred side. The degree to which the arm is affected differs quite substantially.

Preferred shoulder abduction

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	Yes

The discus performances of the F55-F58 athletes did have a significant correlation with their preferred shoulder abduction. The non-preferred and preferred sides of the F55-F58 participants are similarly developed. Athletes from this grouping are also capable of developing more refined throwing techniques because of their functional control of more muscles than athletes from the F52-F54 group.

No significant correlation for F33-F34 shot put performance was found.

Non-preferred grip strength

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	Yes

The discuss performances of the F55-F58 athletes correlated significantly with the test scores. This finding may be because this test is an acceptable measure of upper body strength, and the use of technique to apply strength in the discus is possible for athletes in this class. F52-F54 athletes' performances in discus did not correlate significantly with the test scores, which may reflect their dependence on a factor other than upper body strength to achieve distance in the discus throw.

There was no significant correlation between the non-preferred grip strength of the athletes in the F33-F34 classes and their discus throw. This may be because the non-preferred side is the affected side, and it is difficult to develop strength on the non-preferred side.

Preferred grip strength

Classes	Significant correlation?
F33-34	Yes
F52-54	No
F55-58	Yes

There were significant correlations between preferred grip strength and the discus performances of athletes from the F55-F58 and F33-F34 classes.

Grip strength has been found in able-bodied athletes to be a good indicator of upper body strength. The significant correlation within the disability classes in the discus indicates the relationship between grip strength and upper body strength may also apply to persons with disabilities. Minimal coordination is needed to perform this test. This may lead to true reflection regarding real strength of the athlete with cerebral palsy. All the other strength tests needs a bit of coordination that will definitely influence the scores.

The lack of a significant correlation between discus performances of athletes in the F52-F54 classes and their preferred grip strength could be because technique is more responsible for distance than strength.

Basketball chest pass

Classes	Significant correlation?
F33-34	Yes
F52-54	Yes
F55-58	Yes

There were significant correlations found between the basketball chest pass and the discus performances of athletes form all groups, F33-34, F52-F54 and F55-F58. The basketball chest pass is a good indicator of upper body power for an athlete. The significant correlations are an indication that upper body power is an important factor in sitting discus events.

Basketball overhead pass

Classes	Significant correlation?
F33-34	Yes
F52-54	Yes
F55-58	Yes

There were significant correlations found between the basketball overhead pass and the discus performances of athletes form all groups, F33-34, F52-F54 and F55-F58. The basketball overhead pass is another good indicator of upper body power for an athlete. This test uses slightly different muscles than the chest pass and is more difficult to control. The athletes in this study must have been able to perform the action with sufficient coordination for this to be a valid test of power. The significant correlations are an indication that the basketball overhead pass is also a good indicator of the upper body power needed to throw the discus.

Non-preferred shoulder internal rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. This could be due to the large standard deviations found in the data. This finding does not mean that flexibility is unimportant, but rather that it did not play a significant role in the performance of the athletes who participated in this study. The losses in flexibility in the non-preferred side of the F33-F34 athletes with cerebral palsy, also contributed to the variations in their scores.

Preferred shoulder internal rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. This could be due to the large standard deviations found in the data. This finding does not mean that flexibility is unimportant, but rather that it did not play a significant role in the performance of the athletes who participated in this study.

Non-preferred shoulder external rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. This could be due to the large standard deviations found in the data. This finding does not mean that flexibility is unimportant, but rather that it did not play a significant role in the performance of the athletes who participated in this study. The losses in flexibility in the non-preferred side of the F33-F34 athletes with cerebral palsy, also contributed to the variations in their scores.

Preferred shoulder external rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. This could be due to the large standard deviations found in the data. This finding does not mean that flexibility is unimportant, but rather that it did not play a significant role in the performance of the athletes who participated in this study.

Non-preferred shoulder mobility

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. This could be due to the large standard deviations found in the data. This finding does not mean that flexibility is unimportant, but rather that it did not play a significant role in the performance of the athletes who participated in this study. The losses in flexibility in the non-preferred side of the F33-F34 athletes with cerebral palsy, also contributed to the variations in their scores.

Preferred shoulder mobility

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. This could be due to the large standard deviations found in the data. This finding does not mean that shoulder mobility is unimportant, but rather that it did not play a significant role in the performance of the athletes who participated in this study.

Sorenson Test

Classes	Significant correlation?
F33-34	Does not apply
F52-54	Does not apply
F55-58	No

Athletes in the F55-F58 classes were the only athletes to take the Sorenson test. No significant correlation was found to their discus throw. The range was from 3 seconds to 86 seconds with a standard deviation of 31.5. This gives an indication of the heterogeneity of the group and may help explain the weak correlation.

Abdominal strength

Classes	Significant correlation?
F33-34	Does not apply
F52-54	Does not apply
F55-58	No

Athletes in the F55-F58 classes were the only athletes to take the abdominal strength test. No significant correlation was found with their discus throw. It could be that the use of the abdominal muscles is not always optimised by sitting athletes. The use of strapping may contribute to under-training of the abdominal muscles. Some athletes may not be fully aware of the function capabilities of their abdominal muscles.

Dips

Classes	Significant correlation?
F33-34	Does not apply
F52-54	Does not apply
F55-58	No

Athletes in the F55-F58 classes were the only athletes to perform this test. No significant correlation was found with their discus throw. The range of dips was from 8 to 99 with a standard deviation of 18.8. This is an indication of the heterogeneous nature of the group, which made finding a significant correlation almost impossible. Muscle endurance is widely under estimated in the throwing events, due to the fact that individuals think of the throwing events as strength events and not as endurance events. It may be that very few of the F55-58 athletes draw on their muscle endurance in order to achieve improvements in distance from their first to their final (sixth) throw.

Research Question Three

What are the test items in a valid physical fitness test battery for athletes with physical disabilities who compete in the sitting javelin event?

Valid tests for Javelin F33-F34

- ✓ Preferred shoulder flexion.
- ✓ Basketball chest pass.
- ✓ Basketball overhead pass.
- ✓ Non-preferred grip strength.
- ✓ Preferred grip strength.

Valid tests for Javelin F52-F54

- ✓ Estimated 1 repetition maximum bench press.
- ✓ Non-preferred shoulder flexion.
- ✓ Preferred shoulder flexion.
- ✓ Non-preferred shoulder abduction.
- ✓ Preferred shoulder abduction.
- ✓ Basketball chest pass.
- ✓ Basketball overhead pass.
- ✓ Non-preferred grip strength.
- ✓ Preferred grip strength.
- ✓ Preferred shoulder mobility.

Valid tests for Javelin F55-F58

- ✓ Estimated 1 repetition maximum bench press.
- ✓ Preferred shoulder abduction
- ✓ Basketball chest pass
- ✓ Basketball overhead pass
- ✓ Non-preferred shoulder internal rotation
- ✓ Non-preferred shoulder external rotation.

Table 25. Correlations between javelin performance and test results.

Test	F33-F34	F52-F54	F55-F58
	Javelin	Javelin	Javelin
Sitting height	0.175	0.394	0.385
Weight	0.437	0.349	0.178
Sum of skinfolds	0.649	0.037	0.417
Estimated 1 repetition maximum bench press	•	0.764*	0.532*
Non-preferred shoulder flexion	0.690	0.730*	0.360
Preferred shoulder flexion	0.698*	0.741*	0.359
Non-preferred shoulder abduction	0.606	0.688*	0.405
Preferred shoulder abduction	0.633	0.703*	0.567*
Non-preferred grip strength	0.896*	0.821*	0.482
Preferred grip strength	0.747*	0.769*	0.388
Basketball chest pass	0.885*	0.713*	0.617*
Basketball overhead pass	0.843*	0.829*	0.633*
Non-preferred shoulder internal rotation	0.321	0.163	0.536*
Preferred shoulder internal rotation	0.270	0.281	0.537
Non-preferred shoulder external rotation	0.169	0.383	0.537*
Preferred shoulder external rotation	0.476	0.387	0.343
Non-preferred shoulder mobility	0.773	0.538	0.015
Preferred shoulder mobility	0.719	0.611*	0.096
Sorenson test	•	0.175	0.155
Abdominal strength	•	0.003	0.091
Dips	•	0.383	0.21

* = $p<0.05$

- did not do the test

Comments on each test

Sitting height

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlation was found between sitting height and javelin performance. Due to the longer distances achieved in the javelin as compared to the discus and shot put, the advantage one can get by a higher releasing sitting height may not play such a significant role.

Weight

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlation was found. Excess weight is not as detrimental for performance in sitting events than in standing throwing events. The athlete does not need to carry his/her weight, due to the fact that he/she competes sitting. Performance will not be influenced as much by weight as in standing throwing events.

Sum of skinfolds

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. The fact that the athletes compete from sitting positions means that an excessive amount of body fat will not hinder their performance as much as it would hinder a standing athlete. This means that body fat percentage by itself does not appear to influence performance to a significant degree.

Estimated 1 repetition maximum bench press

Classes	Significant correlation?
F33-34	Does not apply
F52-54	Yes
F55-58	Yes

No bench press was done with athletes in the F33-F34 classes. A significant correlation was found for F52-F54 and F55-F58 athletes between their discus performances and their estimated 1 repetition maximum bench press. The significant correlation between 1 repetition maximum bench press and javelin performance for the F52-F54 and F55-F58 class is an indication that upper body strength makes an important contribution to better javelin throwing performance.

Non -preferred shoulder flexion

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	No

There was a significant correlation between the javelin performances of athletes in the F52-F54 classes and their non-preferred shoulder flexion. The non-preferred sides of the F52-F54 athletes are usually developed in a manner similar to their preferred side. In most instances if the preferred side correlates significantly the non-preferred side might as well. It appears that shoulder flexion muscles are more important for the technique used by athletes in the F52-F54 class.

The throwing technique used by athletes in the F55-F58 classes may vary from that used by athletes in the F52-F54 classes. This may be one explanation for why there is not a significant correlation between javelin performance and this test of shoulder flexibility.

The absence of a significant correlation for F33-F34 javelin performance can be due to the fact that it is the non-preferred arm that is affected by cerebral palsy. The degree to which the arm is affected differs quite substantially among athletes in these classes.

Preferred shoulder flexion

Classes	Significant correlation?
F33-34	Yes
F52-54	Yes
F55-58	No

There were significant correlations between the javelin performances of the F52-F54 and F33-F34 athletes and their preferred shoulder flexion. It could be that strength in the throwing shoulder is particularly important for their technique. The lack of a significant correlation for the athletes in the F55-F58 classes suggests that they may rely on other components more in their throwing technique.

Non-preferred shoulder abduction

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	No

There was a significant correlation between javelin performances of the F52-F54 athletes and their discus performances and their non-preferred shoulder abduction. The non-preferred side of the F52-F54 athletes develops in a similar manner to their preferred side. In most instances if the preferred side correlates significant the non-preferred side will as well. Shoulder abduction appears to be important for the technique use by athletes in the F52-F54 classes. This may not be the case for the athletes in the F55-F58 classses. There was no significant correlation found between their non-preferred should abduction and javelin performance.

No significant correlation was found between non-preferred shoulder abduction and javelin performance for athletes in the F33-F34 classes. This can be due to the fact that it is the non-preferred arm that is affected by cerebral palsy. The amount to which the arm is affected differs quite substantially among athletes in these classes.

Preferred shoulder abduction

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	Yes

Significant correlations were found between preferred should abduction and the javelin performances of athletes in the F52-F54 and F55-F58 classes. Shoulder abduction is important for the javelin action. The reason for the lack of correlation between preferred should abduction and javelin performances of the F33-F34 athletes might be that they rely more on coordination to produce distances in their throws.

Non-preferred grip strength

Classes	Significant correlation?
F33-34	Yes
F52-54	Yes
F55-58	No

Significant correlations were found between the javelin performances of the F52-F54 and F33-F34 athletes and their non-preferred grip strength. These correlations between grip strength and javelin performance is an indication that upper body strength plays an important role in javelin performance. The lack of a significant correlation between non-preferred grip strength and the performances of the F55-F58 athletes may be because these athletes have more mobility and may be able to use more technique to achieve distance than athletes in the other sitting classes.

Preferred grip strength

Classes	Significant correlation?
F33-34	Yes
F52-54	Yes
F55-58	No

Significant correlations were found between the javelin performances of the F52-F54 and F33-F34 athletes and their non-preferred grip strength. These correlations between grip strength and javelin performance is an indication that upper body strength plays an important role in javelin performance. Grip strength is used as a good indicator of upper body strength for able-bodied athletes. Because little coordination is needed to perform this test, it is a good test to measure the strength of athletes with cerebral palsy.

The lack of a significant correlation between non-preferred grip strength and the performances of the F55-F58 athletes may be because these athletes have more mobility and may be able to use more technique to achieve distance than athletes in the other sitting classes.

Basketball chest pass

Classes	Significant correlation?
F33-34	Yes
F52-54	Yes
F55-58	Yes

Significant correlations were found between the javelin performances of athletes in the F33-F34, F52-F54 and F55-F58 and F33-F34 groupings and their basketball chest pass. The basketball chest pass is a good indicator of upper body power for an athlete. The significant correlations are an indication that upper body power is an important factor in sitting javelin events.

Basketball overhead pass

Classes	Significant correlation?
F33-34	Yes
F52-54	Yes
F55-58	Yes

Significant correlations were found between the javelin performances of athletes in the F33-F34, F52-F54 and F55-F58 and F33-F34 groupings and their basketball overhead pass. The basketball overhead pass is a good indicator of upper body power for an athlete. The significant correlations are an indication that upper body power is an important factor in sitting javelin events.

Non-preferred shoulder internal rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	Yes

There was a significant correlation between non-preferred internal shoulder rotation and the javelin performances of athletes in the F55-F58 classes. Flexibility in the non-preferred side for the F55-F58 group can be a result of less muscle bulk that results in more mobility.

The lack of a significant correlation for this flexibility test and the javelin performances of F52-F54 athletes can be due to the large standard deviation found in the data. The lack of significant correlation with the javelin performances of athletes in the F33-F34 classes may be attributed to the fact that it is the non-preferred side that is affected by the cerebral palsy. There was also a great deal of variation in their scores, which makes it difficult to achieve significant correlations.

Preferred shoulder internal rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

No significant correlations were found. The lack of significant correlations for this flexibility test may be due to the large standard deviations found in the data. This shows a great variety in preferred shoulder internal rotation (flexibility) among the participants in this study.

Non-preferred shoulder external rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	Yes

There was a significant correlation between non-preferred shoulder external rotation and the javelin performances of athletes in the F55-F58 classes. Flexibility in the non-preferred side for the F55-F58 group can be a result of less muscle bulk that results in more mobility.

The lack of a significant correlation for this flexibility test and the javelin performances of F52-F54 athletes can be due to the large standard deviation found in the data. The lack of significant correlation with the javelin performances of athletes in the F33-F34 classes may be attributed to the fact that it is the non-preferred side that is affected by the cerebral palsy. There was also a great deal of variation in their scores, which makes it difficult to achieve significant correlations.

Preferred shoulder external rotation

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

The lack of a significant correlation for this flexibility test and the javelin performances of F52-F54 and F55-58 athletes can be due to the large standard deviation found in the data. This may mean that this range of motion is only used by some of the athletes to achieve distance on their throws, while other athletes rely on other components of performance. The lack of significant correlation with the javelin performances of athletes in the F33-F34 classes may be because they rely more on coordination than range of motion to achieve distance in their throws. It can also be noted that there was also a great deal of variation in their scores, which makes it difficult to achieve significant correlations.

Non-preferred shoulder mobility

Classes	Significant correlation?
F33-34	No
F52-54	No
F55-58	No

The lack of a significant correlation for this flexibility test and the javelin performances of F52-F54 and F55-58 athletes can be due to the large standard deviation found in the data. This may mean that this range of motion is only used by some of the athletes to achieve distance on their throws, while other athletes rely on other components of performance. The lack of significant correlation with the javelin performances of athletes in the F33-F34 classes may be attributed to the fact that it is the non-preferred side that is affected by the cerebral palsy. There was also a great deal of variation in their scores, which makes it difficult to achieve significant correlations.

Preferred shoulder mobility

Classes	Significant correlation?
F33-34	No
F52-54	Yes
F55-58	No

There was a significant correlation between the preferred shoulder mobility and the javelin performances of athletes in the F52-F54 classes. The shoulder mobility test is more of a dynamic flexibility test than the others in this test battery and the similarity between this test and the javelin throw is quite good.

The lack of significant correlation between this test and the javelin performances of the other athletes in this study may be due to large standard deviations in the scores. This suggests that some of the athletes were very mobile, and others not. The role of shoulder mobility in throwing the javelin from a sitting position needs more study before its impact can be described.

Sorenson test

Classes	Significant correlation?
F33-34	Did not apply
F52-54	Did not apply
F55-58	No

No significant correlation was found between scores on this test and the javelin performances of athletes in the F55-F58 classes, the only group to take the Sorenson Test. The range of scores was from 12 seconds to 85 seconds with a standard deviation of 29.6. This gives an indication of the heterogeneity of the group and a possible reason for the weak correlation.

Abdominal strength

Classes	Significant correlation?
F33-34	Did not apply
F52-54	Did not apply
F55-58	No

No significant correlation was found between the abdominal strength test and the javelin performances of athletes in the F55-F58 group, the only group to take this test. Abdominal strength should be an important factor in throwing. It is possible that the use of the abdominal muscles is not optimised by many sitting throwers. The use of strapping may promote dependence and an under-training of the abdominal muscles as a result.

Dips:

Classes	Significant correlation?
F33-34	Does not apply
F52-54	Does not apply
F55-58	No

No significant correlation was found between dips and the javelin performances of athletes in the F55-F58 group, the only group to take this test. The range of scores on this test was from 8 to 99 with a standard deviation of 21.4. This is an indication that a significant correlation is almost impossible. Muscle endurance in widely under estimated in the throwing events, perhaps because individuals think of the throwing events as strength events and not as endurance events.

Research Question Four

Are performances on any of the test items particularly good predictors of actual performance during competition in any of the sitting throwing events?

Because this question can only be answered by using multiple regression statistics, the number of athletes in a group must reach a minimum number in order to make calculations meaningful. Only two of the groups within this study had enough subjects to do these statistics: the F55-F58 shot put and the F55-F58 discus. Based on the outcomes of the data processing, the following tests are recommended for testing F55-F58 participants in shot put and/or discus (see Table 26 and 27).

- ✓ Preferred grip strength.
- ✓ Basketball overhead pass.
- ✓ Sitting height.
- ✓ 1 Repetition maximum bench press.
- ✓ Basketball chest pass.

Comments Shot put F55-F58

The two tests that were best in predicting shot put performance were:

- The basketball overhead pass
- Preferred grip strength.

These two tests accounted for 70% of the shot put performance.

Table 26. Multiple regression statistics for the F55-F58 shot put.

Tests	Beta value	MR	R^2	Adjusted R^2
Basketball chest pass Sitting height	0.519* 0.272	0.702	0.493	0.467
Basketball overhead pass Sitting height	0.514* 0.338*	0.722	0.521	0.487
1 Repetition maximum bench press Sitting height	0.520* 0.399*	0.739	0.546	0.510
Preferred grip strength Sitting height	0.707* 0.227	0.842	0.708	0.685
Preferred shoulder flexion Sitting height	0.585* -0.210	0.484	0.235	0.17
Preferred shoulder abduction Sitting height	0.588* -0.190	0.496	0.246	0.186
Basketball chest pass 1 Repetition maximum bench press	0.444* 0.342	0.715	0.512	0.473
Basketball chest pass Preferred grip strength	0.197 0.669*	0.828	0.686	0.661
Basketball chest pass Preferred shoulder flexion	0.624* 0.004	0.627	0.393	0.345
Basketball chest pass Preferred shoulder abduction	0.582* 0.065	0.629	0.395	0.347
Basketball overhead pass 1 Repetition maximum bench press	0.382* 0.447*	0.715	0.511	0.472
Basketball overhead pass Preferred grip strength	0.302* 0.622*	0.850	0.721	0.700
Basketball overhead pass Preferred shoulder flexion	0.358 0.241	0.539	0.290	0.233
Basketball overhead pass Preferred shoulder abduction	0.355 0.289	0.560	0.314	0.259
Preferred shoulder flexion 1 Repetition maximum bench press	0.205 0.479*	0.612	0.375	0.325
Preferred shoulder flexion Preferred grip strength	0.124 0.583*	0.657	0.431	0.384
Preferred shoulder abduction 1 Repetition maximum bench press	0.160 0.408*	0.599	0.359	0.308
Preferred shoulder abduction Preferred grip strength	0.093 0.592*	0.652	0.426	0.378

Multiple regression analysis was used to establish the efficacy of using a pair of measures to predict performance in shot put, classes F55-F58. The order of the entry of the pair of measures was alternated to illustrate the amount of variance accounted for by the second measure over and above that already accounted for by the first measure. The purpose was to identify the best combination among the tests that been used. The adjusted R^2 indicates the percentage of performance that can be accounted for by the two tests in the combination. The following were the top five combinations

1. Basketball Overhead Pass & Preferred Grip Strength
   Adjusted $R^2 = 0.700$.

2. Preferred Grip Strength & Sitting height
   Adjusted $R^2 = 0.685$.

3. Basketball Chest Pass & Preferred Grip Strength
   Adjusted $R^2 = 0.661$.

4. 1 Repetition Maximum Bench Press & Sitting height
   Adjusted $R^2 = 0.510$.

5. Basketball Overhead Pass & Sitting height
   Adjusted $R^2 = 0.487$.

Comments Discus F55-F5

The two tests that were best in predicting discus performance were:

- Basketball overhead pass

- Preferred grip strength.

These two tests accounted for 69.7% of the discus performance.

Table 27. Multiple regression statistics for the F55-F58 Discus.

Tests	Beta value	MR	R^2	Adjusted R^2
Sitting height 1 repetition maximum bench press	0.472* 0.444*	0.75	0.570	0.541
Sitting height Preferred shoulder flexion	0.486* 0.363*	0.713	0.509	0.476
Sitting height Preferred shoulder abduction	0.408* 0.429*	0.729	0.533	0.501
Sitting height Basketball chest pass	0.279* 0.611*	0.807	0.652	0.630
Sitting height Basketball overhead pass	0.322* 0.637*	0.844	0.713	0.695
Sitting height Preferred grip strength	0.375* 0.511*	0.770	0.594	0.567
1 repetition maximum bench press Preferred grip strength	0.262 0.503*	0.708	0.501	0.466
Preferred grip strength Basketball chest pass	0.339* 0.549*	0.813	0.660	0.638
Preferred grip strength Basketball overhead pass	0.359* 0.585*	0.846	0.716	0.697
Basketball overhead pass Basketball chest pass	0.491* 0.398*	0.836	0.699	0.680
Basketball chest pass 1 repetition maximum bench press	0.674* 0.214	0.818	0.670	0.648
Basketball overhead pass 1 Repetition max bench press	0.640* 0.320*	0.837	0.700	0.680
Basketball overhead pass Preferred shoulder flexion	0.679* 0.213	0.807	0.653	0.629
Basketball overhead pass Preferred shoulder abduction	0.622* 0.319*	0.833	0.693	0.673
Basketball chest pass Preferred shoulder flexion	0.730* 0.118	0.806	0.649	0.626
Basketball chest pass Preferred shoulder abduction	0.667* 0.203	0.815	0.664	0.641
Preferred shoulder flexion 1 Repetition maximum bench press	0.317 0.440*	0.668	0.447	0.409
Preferred shoulder abduction 1 Repetition maximum bench press	0.435* 0.373*	0.713	0.508	0.475
1 Repetition maximum bench press Preferred grip strength	0.262 0.503*	0.707	0.500	0.466
Preferred shoulder abduction Preferred grip strength	0.373* 0.486*	0.7511	0.564	0.534
Preferred shoulder flexion Preferred grip strength	0.261 0.548*	0.717	0.513	0.480

Multiple regression analysis was used to establish the efficacy of using a pair of measures to predict performance in discus, classes F55-F58. The order of the entry of the pair of measures was alternated to illustrate the amount of variance accounted for by the second measure over and above that already accounted for by the first measure. The purpose was to identify the best combination among the tests been done. The adjusted R^2 indicates the percentage of performance that can be accounted for by the two tests in the combination. The following were the top five combinations:

1. Preferred Grip Strength & Basketball Overhead Pass
   Adjusted $R^2 = 0.697$.

2. Sitting height & Basketball Overhead Pass
   Adjusted $R^2 = 0.695$.

3. Basketball Overhead Pass & 1 Repetition Maximum Bench Press
   Adjusted $R^2 = 0.680$.

4. Basketball Overhead Pass & Basketball Chest Pass
   Adjusted $R^2 = 0.680$.

5. Basketball Overhead Pass & Preferred Shoulder Abduction
   Adjusted $R^2 =0.673$.

Chapter Five

Conclusions and Recommendations

The purpose of this study was to identify valid tests of physical fitness for individuals with physical disabilities competing in sitting throwing events. Once valid tests were identified, additional statistics were calculated to determine which of the tests measured the more important fitness components and which were the "better" predictors of performance in the sitting shot put, discus and javelin.

Summary

The following conclusions were drawn from this study:

- Physical strength and power were the most important factors for performance when looking at the athletes with disabilities competing in sitting throwing events. The fitness tests achieved the best correlations were the tests of strength and power.
- Sitting height was the only anthropometric measurement that had a significant correlation to throwing performance for some of the classes.
- Neither flexibility nor muscular endurance were significant contributors to throwing performance in any of the events for athletes from any of the classes.
- A multiple regression analysis was completed on the data from F55-F58 groups for shot put and discus. It was found that the following tests were the best predictors of performance of F55-F58 shot put and discus:
    - Sitting height.
    - Basketball overhead pass.
    - Basketball chest pass.

- Grip strength.
- Bench press.

Each of the above conclusions will be discussed separately in the following sections of the chapter.

Strength and Power

A study done by Morrow et al. (1982) on able-bodied throwers indicated that strength was the most important fitness component for the throwers in shot put and discus events, but that no significant relationship was found between strength and javelin performance. The same was found for the athletes with physical disabilities competing in sitting throwing events. Strength in the shot put was found to be critical, all of the strength test achieved a positive correlation. The importance of strength for discus performance differed between the different classes. This indicates that athletes from the different classes may use different techniques, which results in difference in the use of strength. The relationship between strength and javelin performance was also mixed. Some of the classes did have significant correlations between strength and performance on some of the strength tests.

The two tests of upper body power correlated significantly with the throwing performances achieved by all the groups and in all three events. It seems that power in the upper body is the best predictor of performance and therefore is the fitness component that should receive the most attention during training. Abdominal muscle strength did not play any significant role in the performance of the throwers in this study.

The strength tests recommended for use with sitting throwers are the basketball chest pass, the basketball overhead pass, grip strength and bench press (if equipment is available).

Anthropometry

The only significant test was that of sitting height. The athletes competing in the groups F33 and F34 did not show any significant correlation between sitting height and performance. The sitting height of athletes in groups F52-F54 and F55-F58 correlated significantly with shot put performance. There was also a significant correlation between sitting height and the discus throws of athletes in the F55-F58 classes. This indicates that the technique factor of releasing height does play a role in these two groups. A person who has a higher sitting height will have an advantage over those who have a shorter sitting height.

Sitting height is an important test and is recommended. Although it did not have a significant correlation with sport performance, measuring sum of skinfolds is recommended as an indicator of obesity in order to identify athletes whose general health may be at-risk.

Flexibility and Muscle Endurance

Almost no significant correlations were found between flexibility and performance. Although there were some of the tests that correlated significantly with javelin performance, flexibility did not appear to be a critical factor for successful performance. The lack of significant correlations should not lead to the conclusion that flexibility training is unnecessary. Good mobility and flexibility is necessary to perform the throwing techniques. It is also known that improved flexibility can decrease the chances for injuries. Increased flexibility results in longer performances for muscle contraction. The longer the performance for muscle contraction, the stronger the contraction. Flexibility should be important in the light of the results of strength's correlation to performance. Perhaps flexibility is lacking in the preparation of these athletes, which is why it does not currently figure in their performance.

The rule that each athlete competing in sitting throwing events must finish all of his/her throws before the next athlete throws, suggests that muscle endurance should be helpful in the sitting throwing events. However, the lack of significant correlation between muscle endurance and performance may indicate that the time the athlete has between each throw is enough to recover fully.

Although very few of the flexibility tests correlated with performance, flexibility testing is recommended in order to identify athletes who are not getting sufficient range of motion in their throwing actions. No muscle endurance tests are recommended.

Technique

The two major contributors to sport performance are technique (skill) and the physical capabilities of the individual. As noted above, strength and power were the physical fitness components that appeared to have the greatest affect on performance in the sitting throwing events of the athletes who participated in this study. But what about their skill or technique ? Did the athletes in this study have technically correct throwing actions, so that we could say with confidence that the differences in their performances could be attributed to differences in their strength and power? Or are they using poor technique and relying on their strength and power to produce winning results?

To address these questions, two expert athletics coaches were asked to make independent and objective ratings of the throwing techniques of a random selection of throwers who participated in this study. On the day of competition, the throws of the athletes in the sample were video taped. For shot put and discus the camera was positioned to tape from the 45° line in front of the circle on the athletes' throwing-arm side. For the javelin, the camera was positioned to tape the athletes' throws from the back and if possible, a second tape was made from the 45° line in front of the releasing area. The two experts viewed the tape after the event, and could replay the throw of any of the athletes. They evaluated the technique of each athlete separately on a scale of:

1. Poor.
2. Weak.
3. Average.
4. Good.
5. Very good.

They then discussed their ratings and agreed on a final score. The results are presented in Table 28. A group mean was calculated for each of the groups for each of the events. Then, a correlation coefficient was calculated with throwing performance to determine if the throwers with the "better technique" were the throwers with the better performances.

Table 28. Average technique ratings of sitting throwers.

Group	N	Mean	Range		SD	r
			Low	High		
Shot put F33-F34	9	2.50	1.5	3	0.559	0.304
Shot put F52-F54	9	2.50	2	4	0.707	0.932*
Shot put F55-F58	20	2.73	2	4	0.638	0.515*
Discus F33-F34	6	2.08	1	3	0.665	0.931*
Discus F52-F54	6	2.33	1.5	3	0.606	0.712
Discus F55-F58	24	2.50	1	4	0.737	0.341
Javelin F33-F34	7	2.29	1.5	3	0.699	0.685
Javelin F52-F54	8	2.19	1.5	3	0.530	0.797*
Javelin F55-F58	7	2.35	2	3	0.475	0.785*

* $p<0.05$

The average scores for all groups in all events were between 2.08 and 2.73. This is an indication that the technique of the athletes can improve a lot. Not one person was rated "very good," although some of them did score 4 (good). Significant correlations were found between performances and techniques in:

Shot put F52-F54.

Shot put F55-F58.

Discus F33-F34.

Javelin F52-F54.

Javelin F55-F58.

An interesting observation is that shot put F52-F54 and shot put F55-F58 were also the groups that displayed a significant correlation between performance and strength and power. This confirms that for this group, strength and power combine with technique to produce success. However, for athletes in the shot put F33-F34 group, neither techniques nor strength and power correlated significantly with performance. One wonders what it is that lifts the best performer above the rest in this class? One possibility is that each individual must work out his/her own pattern of coordination, so that an expert coach would not pick-up their "correct" technique in F33-F34 shot put, until after actually working with each individual in order to discover their functional movement potential and what the best technique is for each individual. The technique might look not very good, but it might be the best for that individual.

The almost perfect correlation between technique and performance in the discus for the F33-F34 athletes demonstrates that technique is indeed critical for athletes with cerebral palsy. An F33-F34 athlete with good power and good technique are almost certain of a good performance. The lack of significant correlation between technique and performance in the F55-F58 class indicate that they rely on their strength and power for good performance. For athletes in the F52-F54 classes, power appeared to be the determining factor in successful performance in the discus.

There was a significant correlation between javelin technique and performance for the athletes in the F52-F54 and F55-F58 classes, who also rely on their strength and power. Flexibility also had a role to play in performance for athletes in the F55-F58 classes. No significant correlation was found between technique and performance in the F33-F34 javelin. Power and strength were the two factors that contributing most to the javelin performance of the athletes in the F33-F34 classes.

Performance Prediction

The fact that certain of the physical fitness tests do correlate significantly with performance leads to the possibility that the performance of an individual in one of the sitting throwing events could be predicted based on their scores on selected fitness tests. Linear regression equations can be used to determine the performance an athlete needs to achieve in the more significant tests to achieve a certain performance in one of the events.

Linear Regression Equations

Linear regression equations were computed to describe the relationship between performances on those physical fitness tests found to correlate significantly with performance, and performance in the event. Entering the value for the fitness test will allow computation of the predicted distance in the event. Entering the distance in the event will allow computation of the value on the fitness test.

Table 29. Linear regression equations Shot put F33-F34

Shot put F33-F34
Basketball Chest Pass = 0.17965 + 1.2398*Shot put Performance
Preferred Grip Strength = 3.788 + 5.8495*Shot put Performance

Table 30. Linear regression equations Shot put F52-F54

Shot put F52-F54
Basketball Chest Pass = -0.0047 + 1.3481*Shot put Performance
Non-Preferred Grip Strength = -3.205 + 7.5796*Shot put Performance
Preferred Grip Strength = -6.896 +8.0272*Shot put Performance
Basketball Overhead Pass = 0.95013 + 1.0660*Shot put Performance
1 Repetition Maximum Bench Press = -2.835 + 11.089*Shot put Performance
Non-Preferred Shoulder Flexion = -0.3557 + 1.3016*Shot put Performance
Preferred Shoulder Flexion = -0.6528 + 1.3462*Shot put Performance
Non-Preferred Shoulder Abduction = -2,010 +1.7661* Shot put Performance
Preferred Shoulder Abduction = -1.743 + 1.7454* Shot put Performance

Table 31. Linear regression equations Shot put F55-F58

Shot Put F55-F58
Basketball chest pass = 1.7482 + 0.94948*Shot put performance
Preferred grip strength = -4.367 + 7.4302*Shot put performance
Basketball overhead pass = 1.8832 + 0.76545*Shot put performance
1 Repetition maximum bench press = -5.298 + 12.407*Shot put performance
Preferred shoulder flexion = 1.2498 + 0.82305*Shot put performance
Preferred shoulder abduction = 0.55554 + 1.0412* Shot put performance

Table 32. Linear regression equations Discus F33-F34

Discus F33-F34
Basketball chest pass = 1.4251 + 0.40273*Discus performance
Preferred grip strength = 10.26 + 1.836*Discus performance
Basketball overhead pass = 1.4475 + 0.331111*Discus performance
Sum of skinfolds = 70.047 – 3.911* Discus performance

Table 33. Linear regression equations Discus F52-F54

Discus F52-F54
Basketball chest pass = 0.93281 + 0.47943*Discus performance
Basketball overhead pass = 1.0668 + 0.43218*Discus performance

Table 34. Linear regression equations Discus F55-F58

Discus F55-F58
Sitting height = 64.360 + 1.2107*Discus performance
1 repetition maximum bench press = 13.611 + 3.0998*Discus performance
Non-preferred shoulder flexion = 1.9063 + 0.26600*Discus performance
Preferred shoulder flexion = 2.2207 + 0.2447*Discus performance
Non-preferred shoulder abduction = 1.7102 +0.27427*Discus performance
Preferred shoulder abduction = 1.5873 + 0.32831*Discus performance
Basketball chest pass = 2.0922 + 0.33989*Discus performance
Non-preferred grip strength = 9.0865 + 1.4680* Discus performance
Preferred grip strength = 7.1083 + 1.7881*Discus performance
Basketball overhead pass = 2.1908 + 0.26594*Discus performance

Table 35. Linear regression equations Javelin F33-F34

Javelin F33-F34
Preferred shoulder flexion = -0.343 + 0.67875*Javelin performance
Basketball chest pass = -0.5205 + 0.66712*Javelin performance
Basketball overhead pass = 1.5245 + 0.34369*Javelin performance
Non-preferred grip strength = -24.699 + 5.5055* Javelin performance
Preferred grip strength = 6.5302 + 2.7265*Javelin performance

Table 36. Linear regression equations Javelin F52-F54

Javelin F52-F54
1 Repetition maximum bench press = -0.5024 + 4.7408*Javelin performance
Non-preferred shoulder flexion = 0.86387 +0.46294*Javelin performance
Preferred shoulder flexion = 0.67126 +0.46891*Javelin performance
Non-preferred shoulder abduction = 0.32325 + 0.58299*Javelin performance
Preferred shoulder abduction = 0.32991 + 0.58952*Javelin performance
Basketball chest pass = 1.8845 + 0.43739*Javelin performance
Non-preferred grip strength = 1.8412 + 2.9474* Javelin performance
Preferred grip strength = -2.325 + 3.2367*Javelin performance
Basketball overhead pass = 1.6302 + 0.41829*Javelin performance
Preferred shoulder mobility = 3.6551 – 0.1008*Javelin performance

Table 37. Linear regression equations Javelin F55-F58

Javelin F55-F58
1 Repetition maximum bench press = 21.051 + 2.4624*Javelin performance
Preferred shoulder abduction = 2.2891 + 0.28642*Javelin performance
Basketball chest pass = 3.535 + 0.21919*Javelin performance
Basketball overhead pass = 3.5411 + 0.14854* Javelin performance
Preferred grip strength = 15.613 + 1.3121*Javelin performance
Non-preferred grip strength = 9.3263 + 1.5291*Javelin performance
Non-preferred shoulder internal rotation = 8.1439 + 3.4500*Javelin performance
Preferred shoulder internal rotation = 15.230 +3.6604*Javelin performance
Non-preferred shoulder external rotation= 22.928 + 4.0626*Javelin performance

Recommendations

One problem with this study was that some of the elite throwers did not volunteer to participate. Specific targeted recruitment of elite subjects is recommended for future studies. It was also unfortunate that there were too few numbers in each class to do a single class correlation. Classes had to be combined – as they sometimes are in competition. The classes were combined according to the movement potentials of the athletes. However, it is desirable to keep the heterogeneity within a group as small as possible.

Certain strategies that were followed and worked really well:

- The two training days to prepare the testers helped to familiarise them with the tests and different aspects to expect. They operated well and efficiently during the data gathering.

- The involvement of the team managers was helpful. Their support must be regarded as critical to the success of any research conducted at an event.

- The feedback after the testing, delivered to each athlete as a personal physical fitness report, was met with great enthusiasm and appreciation.

Future Research

The following recommendations are made based on the results of this study:

- This research has identified valid tests. The flowchart recommended by Wilson and Strand (1995) recommends that after a test is valid, reliability and objectivity should be determined. This can be a focus point of a future study.

- If the tests are found to be valid, reliable and objective, focus should be put on developing norms to accompany these tests. Developing norms will definitely be of great use for athletes with disabilities. Sport-specific and disability-specific norms are much needed in disability sport.

- The last step in Strand and Wilson's (1993) flowchart is the construction of a test manual. Sports scientist working with disability sport as well as the athletes themselves will also welcome a test manual specific for disability sport.

- The developing of valid, reliable and objective tests can also help in the development of tests that will be beneficial for talent identification for sport specific events. If certain tests are important for the event, then these tests can be use to determine if someone could become a good athlete in that specific sport. No sport specific technique is required for any of the tests identified in this study.

- Testing more athletes in the different classes will allow multiple regression analysis on classes other than F55-F58 shot put and discus. This can result in the identification of minimal test batteries that will give enough information about an athlete's physical fitness to support the design of meaningful training programmes.

- It would be very interesting to develop class-specific fitness tests. Maybe some of these class-specific tests could be incorporated into the classification system.

- As documented in this study, the technique scores of many sitting throwers were "shocking" when one considers they were performing at the National Championships. Technique analysis for the different classes and in different events will help the coaches within disability sport to determine what is "optimal" technique. Once this is defined, athletes can be coached to improve their standards.

Conclusions

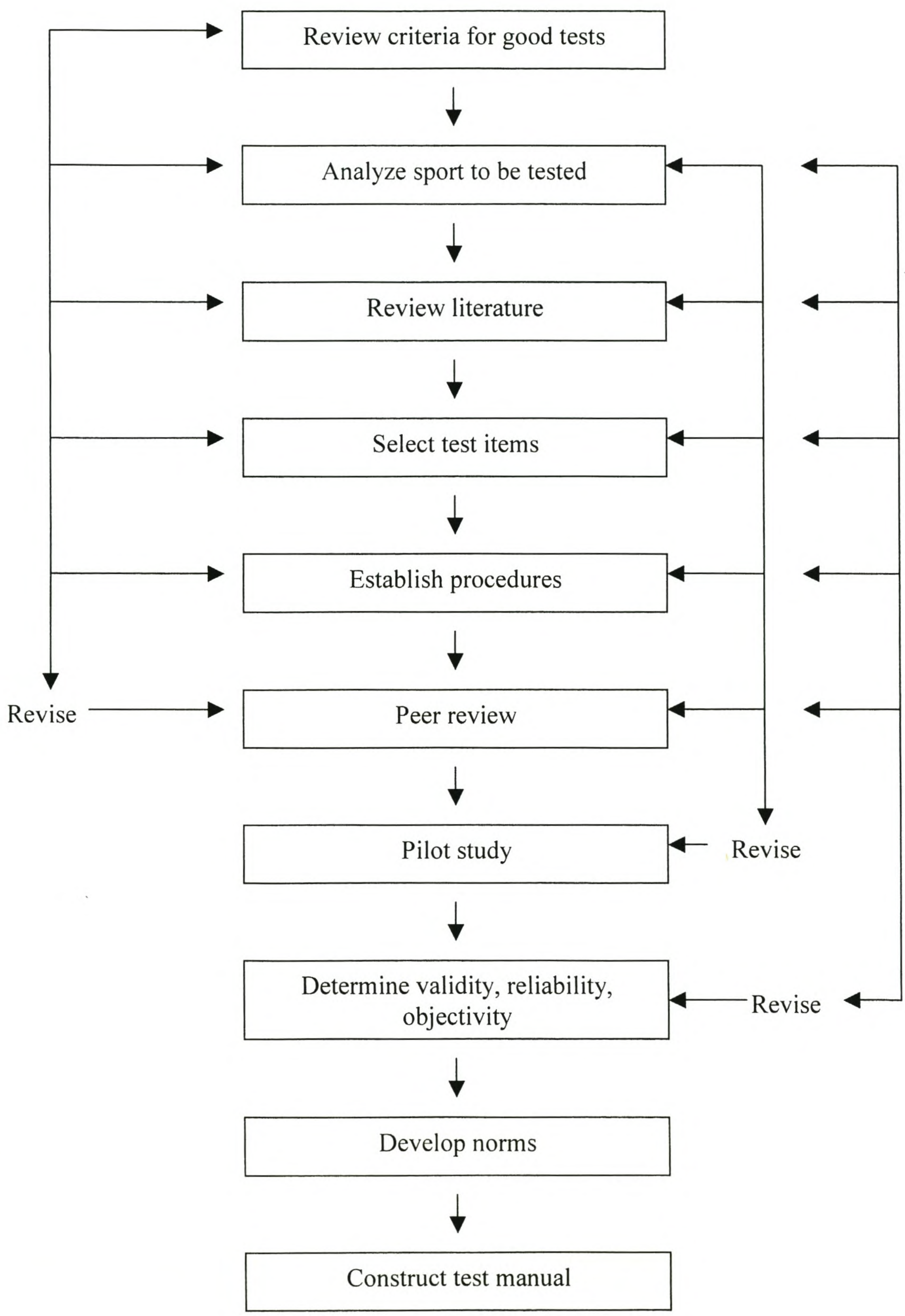
Research in the area of athletes with disabilities is very limited. Most research completed on individuals with disabilities addresses issues related to their physical health. Although health is an important factor, participation in disability sport has unique requirements. As disability sport receives increasing media coverage and appreciation, competition is getting tougher and athletes must train seriously if they hope to achieve. Sport science regarding physical training and performance of the individual with disabilities must keep pace if it is going to support these athletes who are fighting for recognition.

This study was intended to improve the physical fitness test batteries administered to athletes with disabilities who compete in the sitting throwing events. The validity of the tests are now scientifically-based and not simply administered because they are valid for able-bodied athletes. The tests identified for each group in each event should be valid for any athletes with disabilities who are from the same classes competing in the same events.

Although the main focus of the study was to establish valid tests for sitting throwing events, certain limitations regarding the athletes' performances were underlined. Many of the athletes with disabilities in South Africa need to improve their technique in order to improve their performance. An athlete can only improve their technique if he/she has a coach with the knowledge to help the athlete. Coaching athletes with disabilities should be improved with the correct knowledge and support.

Appendix A

TEN- STEP FLOW CHART FOR TEST CONSTRUCTION (Strand & Wilson:1993:10)



Appendix B

TEST BATTERY: SITTING THROWING EVENTS

A) The aim of physiological assessment is to assess the individual athlete's maximal capabilities. All assessments are selected according to the abilities of athletes in each classification. In some cases individuals may be able to perform tests that were not intended for their level of classification.

B) The test situation should simulate the competitive situation as closely as possible, e.g. an athlete who can stand and walk, yet who is classified to throw from a wheelchair or throwing device, must take all the tests for wheelchair throwers. None of his/her tests should be taken while standing.

C) Make careful notes on any adjustments made in any test protocol.

ANTHROPOMETRY

SITTING HEIGHT

Aim: To determine sitting height for those athletes unable to weight-bear or stand erect, the height measurement is taken while sitting against the wall.

Equipment: Metric measuring tape.
Set square.

Procedure: Sitting height is the distance from the vertex to the floor when the seated athlete is instructed to sit tall and gentle traction applied to the mandible. This measurement is usually made when the subject is seated on the floor with the legs as straight as possible. An assistant orients the athlete's head in the Frankfort plane, instructs him or her to take a breath and sit as tall as possible, and applies gentle traction to the mandible. The anthropometrist positions the anthropometer on the sitting base and brings the branch down, crunching the hair and making firm contact with the vertex.

Scoring The distance from the base sitting surface to the branch of the anthropometer is measured in cm to the nearest cm.

WEIGHT

Aim: Measuring body mass.

Equipment: A calibrated scale with a chair mounted on the scale.

Procedure: Body mass should be recorded on a calibrated scale and recorded to the nearest 100 g. Athletes who wear prostheses should be weighed without the prostheses if possible. If not possible notes should be made.

Scoring: Body mass to nearest 100g.

SKINFOLDS

Aim: Calculation of sum of skinfolds.

Equipment: Skinfold calliper.

Procedure: The skinfold calliper reading is a measurement of the compressed thickness of a double layer of skin and the underlying subcutaneous tissue, which is assumed to be adipose tissue. The skinfold thickness is measured by grasping a fold of skin and the underlying subcutaneous tissue between the thumb and forefinger, 1-2 cm above the site that is to be measured. The fold is pulled away from the underlying muscle and the jaws of the callipers are placed on either side of the site, at a depth of approximately 1cm. The skinfold is held firmly throughout the application of the calliper and the reading is taken when the needle becomes steady after the full pressure of the calliper jaws has been applied. The callipers must be applied at right angles to the fold at all times.

Scoring: All measurements are recorded on the athlete's preferred side except for the abdominal skinfold, which is recorded on the athlete's non-preferred side. The measurement is recorded in mm (required accuracy < 1.5mm).

Triceps: Measured from the back on the posterior surface of the arm midway between the top of the shoulder (acromion process) and the elbow (olecranon process). The upper limb should hang loosely by the side with the athlete in a standing position.

Biceps: Measured from the front on the anterior surface of the arm midway between the top of the shoulder and the elbow. The athlete stands in the same position as for the triceps measurement.

Subscapular: Measured just below the inferior angle of the scapula with the fold in an oblique plane descending laterally (outwards) and downwards at an angle of approximately 45° to the horizontal.

FLEXIBILITY

SHOULDER INTERNAL & EXTERNAL ROTATION

Aim: To measure flexibility of the shoulder girdle.

Equipment: Goniometer
Firm bed or plinth

Procedure: The athlete is supine on the bed/table with the arm abducted to 90°, the elbow flexed to 90° and the forearm pronates perpendicular to the table. The moving arm of the goniometer is aligned along the ulna using the styloid process as the reference point. The fulcrum is placed over the olecranon, between the medial and lateral epicondyles of the humerus. The stationary arm of the goniometer is placed perpendicular to the ground but pointing downwards.

External rotation is recorded as the maximal movement of the forearm from the upright, in neutral position to a position of full backward rotation.

Internal rotation is from neutral towards a forwardly, rotated position. The athlete's back and shoulder must not loose contact with the plinth during the test, to assure contact a test helper can push the shoulder gently towards the plinth.

Scoring: The angle of back and forward rotation is recorded.

SHOULDER MOBILITY

Aim: The shoulder mobility test is used to assess bilateral shoulder range of motion combining internal rotation with adduction and external rotation with abduction.

Equipment: Tape Measure

Procedure: The tester first determines the athlete's hand length by measuring the distance from the distal wrist crease to the tip of the third digit. The athlete is instructed to make a fist with each hand, placing the thumb inside the fist. They are then asked to assume a maximally adducted and internally rotated position with one shoulder, and a maximally abducted and externally rotated position with the other. During the test the hands should remain in a fist and they should be placed on the back in one smooth motion.

Scoring: The tester then measures the distance between the two fists. Perform the shoulder mobility test as many as 3 times bilaterally. Give a score between 0 – 3.

0 = The athlete will receive a score of zero if pain is associated with any portion of this test. It is recommended that a medical professional should perform a thorough evaluation of the painful area.

1 = Fists fall within two hand lengths
2 = Fists should be within one and a half lengths
3 = Fists should be within one hand length

POWER

BASKETBALL THROW – CHEST PASS

Aim: To measure upper body strength.

Equipment: No. 7 basketball.
Tape measure.

Procedures: The athlete is seated on the floor with his/her back against the wall with legs as straight as possible. The back and shoulders should never loose contact with the wall. The ball is grasped firmly by both hands and pushed from the centre of the chest. Athletes should be instructed on the proper angle of release to achieve maximum distance, this can be demonstrated by showing athletes how maximum performance is effected if the ball is released too high or too low. Athletes should be given three trials.

Scoring: The total distance is measured from the throwing line to the point where the ball first lands on the surface. Record the result of the best trial.

BASKETBALL THROW – OVERHEAD PASS

Aim: To measure upper body strength.

Equipment: No. 7 basketball.
Tape measure.

Procedures: The athlete is seated on the floor with his/her back against the wall with legs as straight as possible. The back and shoulders should never loose contact with the wall The athlete holds the ball with both hands above his/her head, then throws the ball with an even two-handed motion as far as possible. Athletes should be instructed on the proper angle of release to achieve maximum distance. This can be demonstrated by showing athletes how maximum performance is effected if the ball is released too high or too low. Athletes should be given three trials.

Scoring: The total distance is measured from the throwing line to the point where the ball first lands on the surface. Record the result of the best trial.

Comments: Wheelchair athletes perform the tests in their chair with the brakes on, or any other chair that is stabilised by another person holding it. Care must be taken that the chair is thoroughly stabilised in cases where the brakes of the wheelchair are faulty.

Normative data No normative date available.

STRENGTH

BENCH PRESS

Aim: To determine upper body strength.

Equipment: Bench.
Olympic bar.
Weights.

Procedure: For this exercise, the player lies supine on a bench with their feet flat on the floor and their hips and shoulders in contact with the bench. An Olympic bar is gripped 5 - 10 cm wider than shoulder width, so that when the bar is placed on the chest, the elbow joints are flexed to approximately 90 degrees. The player commences this lift by lowering the bar, under control, to the centre of the chest, touching the chest lightly (no bouncing the bar on the chest) and then extending upwards until the arms are in a fully locked position. The player is advised to inhale when lowering the weight and exhale when pressing it. Strapping is allowed for those individuals without functional abdominal muscles. The strapping should stabilize and secure the individual.

There are several reasons for disqualifying a lift, and these include:

- lifting the buttocks, during the movement
- bouncing the bar off the chest
- uneven extension of the arms
- any touching of the bar by the spotter

Scoring: An athlete gets three chances. The weight (bar weight added) is recorded and the one rep max is predicted.

All values are expressed in kilograms.

6 Reps	1RM	6 reps	1RM	6 reps	1RM	6 reps	1RM	6 reps	1RM
5	6	105	126	205	246	305	365	405	485
10	12	110	132	210	251	310	371	410	491
15	18	115	138	215	257	315	377	415	497
20	24	120	144	220	263	320	383	420	503
25	30	125	150	225	269	325	389	425	509
30	36	130	156	230	275	330	395	430	515
35	42	135	162	235	281	335	401	435	521
40	48	140	168	240	287	340	407	440	527
45	54	145	174	245	293	345	413	445	533
50	60	150	180	250	299	350	419	450	539
55	66	155	186	255	305	355	425	455	545
60	72	160	192	260	311	360	431	460	551
65	78	165	198	265	317	365	437	465	557
70	84	170	204	270	323	370	443	470	563
75	90	175	210	275	329	375	449	475	569
80	96	180	216	280	335	380	455	480	575
85	102	185	222	285	341	385	461	485	581
90	108	190	228	290	347	390	467	490	587
95	114	195	234	295	353	395	473	495	593
100	120	200	240	300	359	400	479	500	599

GRIP STRENGTH

Aim: To measure the isometric grip strength of each hand.

Equipment: Hand dynamometer.

Procedure: The athlete sits with the arm extended and approximately 45° from the side of the body. The athlete proceeds to squeeze the dynamometer as vigorously as possible. The hand holding the dynamometer is not allowed to touch the body while the test is being administered. The athlete is allowed two attempts with at least 4 min between each attempt.

Scoring: Record the score for each hand to the nearest 0.5kg.

ABDOMINAL STRENGTH

Aim: The abdominal stage test is a graded test for abdominal strength. Each of the seven stages becomes progressively more difficult as the positions of the hands and arms are modified. These modifications plus the use of 2.5 and 5 kg discs places increasing stress on the abdominal musculature. Strict control over the technique being utilized provides a reliable indicator of abdominal strength. The aim is to accomplish as many of the stages as possible.

Equipment: 2.5kg and 5kg weight
Exercise mat

Procedure:

- Starting position: Lying supine on the floor with a 90° bend at the knee. The feet-without shoes- should be comfortable apart, in contact with the floor, and not held.
- All movements are to be conducted in a smooth, controlled manner.

Any attempt is unsuccessful if the athlete:

- lifts either foot partially or totally of the floor,
- throws the arms and or head forward in a jerky manner,
- moves the arms from the nominated position,
- lifts the hips of the floor,
- fails to maintain a 90° angle at the knee, or is unable to complete the nominated sit-up.

STAGE 1: Palms over knees

Arms are straight with hands resting on thighs. Move forward until the fingers are touching the patella.

STAGE 2: Elbows over knees

Arms straight with hands resting on thighs. Move forward until elbows are touching the patella.

STAGE 3: Forearms to thighs

Arms across and in contact with the abdomen with hands gripping opposite elbows. Move forward until the forearms touch mid-thighs.

STAGE 4: Elbows to mid-thighs

Arms across and in contact with the chest with hands gripping the opposite shoulders. Move forward until the elbows touch the mid-thighs.

STAGE 5: Chest to thighs

Arms bend behind the head with the hands gripping opposite shoulders. Move forward until the chest touches the thighs.

STAGE 6: Chest to thighs with 2.5kg

Arms bent behind the head with the hands crossed and holding a 2.5kg mass. Move forward until the chest touches the thighs.

STAGE 7: Chest to thighs with 5 kg mass

Arms bent behind the head with the hands crossed and holding a 5 kg mass. Move forward until the chest touches the thighs.

<u>Scoring:</u> The athlete is allowed three attempts to pass each stage. The athlete's score is the last stage completed.

Stage 1 **Stage 2** **Stage 3** **Stage 4** **Stage 5** **Stage 6**

SHOULDER FLEXION

Aim: To determine shoulder flexion muscle strength

Equipment: Range of lose weights
Second administrator.
Straps to tie weight to hand.
Straps to fasten to chair

Procedure: The athlete do one arm at a time. Make sure that if the athlete use straps to hold the weight that it is tight and secure. Fasten the athlete to the chair with another strap to obtain stability. The second administrator, push the athlete's opposite shoulder down to give support. The athlete raises the lose weight until arm is horizontal to ground, in a 90° shoulder flexion. Repeat six times.

Scoring: The maximal weight an athlete can lift six times repetitively is his/her 6RM, use the table to get the 1RM.

SHOULDER ABDUCTION

Aim: To determine shoulder abductor muscle strength.

Equipment: Range of lose weights
Second administrator.
Straps to tie weight to hand.
Straps to fasten to chair.

Procedure: The athlete do one arm at a time. Make sure that if the athlete use straps to hold the weight that it is tight and secure. Fasten the athlete to the chair with another strap to obtain stability. The second administrator, push the athlete's opposite shoulder down to give support. The athlete raises the lose weight until arm is horizontal to ground and 90° horizontal abduction. Repeat six times.

Scoring: The maximal weight an athlete can lift six times repetitively is his/her 6RM, use the table to get the 1RM.

MUSCLE ENDURANCE

ADAPTED DIPS

Aim: To measure muscle endurance of the arms and shoulder girdle.

Equipment: Benches
Stopwatch

Procedure: The athlete assumes a position where the legs are supported on the ground, as straight as possible, bend at the hips, back facing bench and arms supporting on the bench. The athlete starts with arms straight and bend it till a 90° angle is formed at the elbows. He/she then pushes back to a straight-arm support position and continues for as many repetition as possible.

Scoring: The score is the number of correct dips performed until exhaustion.

SORENSON BACK EXTENSION

Aim: To determine isometric trunk extensor endurance.

Facility: Small area with flat surface.

Equipment: Table/bench.
Stop watch.

Procedure: The athlete lies prone on an examination bench so that the upper body is unsupported allowing the individual to pivot around the edge of the bench. The buttocks and legs are fixed. This can be done either by means of straps or a test administrator holding the legs down. Allow the athlete to pivot so that the arms can reach the floor and support the upper body.

At the command to start the test, the athlete raises his/her upper body to horizontal position. The arms are folded across the chest, the face facing the floor. The individual holds this position as long as possible. The tester must ensure that a horizontal position is maintained. The test is terminated if the individual cannot maintain a horizontal position, the arms leave the chest or the head is raised.

Scoring: The criterion performance is 240 seconds (4 minutes). If the individual fatigues before 240 seconds, record the time to exhaustion in seconds. If an individual can hold the position for longer than 240 seconds, allow the individual to continue and record the time to exhaustion.

Appendix C

DATA

Table 1: Descriptive Analyses Shot put F52-F54

Descriptive Statistics	SHOT PUT F52-F54				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Performance distance	12.00	4.36	2.72	7.83	1.74
Technique	9.00	2.50	2.00	4.00	0.71
Sitting Height	12.00	82.47	70.00	98.00	8.93
Weight	12.00	70.69	34.50	119.65	26.71
Sum of skinfolds	12.00	46.38	18.20	93.80	23.39
Estimated 1 Repetition Maximum Bench Press	10.00	46.20	18.00	84.00	23.64
Non Preferred Shoulder Flexion	10.00	5.40	3.50	10.00	2.54
Preferred Shoulder Flexion	10.00	5.30	3.50	10.00	2.59
Non-Preferred Shoulder Abduction	10.00	5.80	3.50	14.00	3.48
Preferred Shoulder Abduction	10.00	5.98	3.50	14.00	3.38
Basketball Chest Pass	12.00	5.87	1.60	9.80	2.74
Basketball Overhead Pass	12.00	5.75	3.40	9.80	2.09
Non-Preferred Shoulder Internal rotation	12.00	55.17	26.00	88.00	16.42
Preferred Shoulder Internal rotation	12.00	66.42	39.00	102.00	17.24
Non-Preferred shoulder external rotation	12.00	74.67	54.00	94.00	12.64
Preferred Shoulder External Rotation	12.00	82.08	54.00	98.00	12.42
Non-Preferred Shoulder Mobility	12.00	2.33	1.00	3.00	0.78
Preferred Shoulder mobility	12.00	2.50	1.00	3.00	0.67
Non-Preferred Grip Strength	9.00	30.67	16.00	61.00	15.56
Preferred Grip Strength	10.00	28.60	5.00	63.00	17.24

Table 2: Correlations Shot put F52-F54

CORRELATIONS SHOT PUT F52-F54 PERFORMANCE TO FITNESS TESTS				
	N	R	R*R	P
Performance Distance	12.00	1.00	1.00	
Technique	9.00	0.93	0.87	0.00
Sitting Height	12.00	0.82	0.67	0.00
Weight	12.00	0.72	0.52	0.01
Sum of Skinfolds	12.00	0.18	0.03	0.58
Estimated 1 Repetition Maximum Bench Press	10.00	0.86*	0.73	0.00
Non-Preferred Shoulder Flexion	10.00	0.94*	0.88	0.00
Preferred Shoulder Flexion	10.00	0.95*	0.90	0.00
Non-Preferred Shoulder Abduction	10.00	0.93*	0.86	0.00
Preferred Shoulder Abduction	10.00	0.94*	0.89	0.00
Basketball Chest pass	12.00	0.86*	0.73	0.00
Basketball Overhead pass	11.00	0.95*	0.91	0.00
Non-Preferred Shoulder Internal Rotation	12.00	0.30	0.09	0.35
Preferred Shoulder Internal Rotation	12.00	0.39	0.16	0.21
Non-Preferred Shoulder External Rotation	12.00	0.47	0.22	0.12
Preferred Shoulder External Rotation	12.00	0.23	0.05	0.48
Non-Preferred Shoulder Mobility	12.00	0.34	0.11	0.29
Preferred Shoulder Mobility	12.00	0.52	0.27	0.09
Non-Preferred Grip Strength	9.00	0.94*	0.88	0.00
Preferred Grip Strength	10.00	0.85*	0.72	0.00

* = $P<0.05$

Table 3: Descriptive analyses Shot put F55-F58

Descriptive Statistics	SHOT PUT F55-F58				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Performance Distance	31.00	4.50	3.02	6.27	0.98
Technique	20.00	2.73	2.00	4.00	0.64
Sitting Height	31.00	79.22	61.00	89.00	5.47
Weight	31.00	54.51	32.30	81.70	12.48
Sum of Skinfolds	31.00	36.31	12.00	84.20	22.52
Estimated 1 Repetition Maximum Bench Press	28.00	50.43	24.00	88.00	18.84
Non-Preferred Shoulder Flexion	27.00	4.84	2.00	7.50	1.48
Preferred Shoulder Flexion	28.00	4.95	3.25	7.50	1.33
Non-Preferred Shoulder Abduction	27.00	4.90	2.00	8.50	1.60
Preferred Shoulder Abduction	28.00	5.23	3.25	10.00	1.71
Basketball Chest ass	31.00	6.02	3.50	9.10	1.40
Basketball Overhead Pass	31.00	5.33	3.20	8.70	1.15
Non-Preferred Shoulder Internal Rotation	29.00	45.55	15.00	82.00	21.71
Preferred Shoulder Internal Rotation	30.00	56.40	15.00	96.00	23.02
Non-Preferred Shoulder External Rotation	30.00	67.10	14.00	119.00	26.42
Preferred Shoulder External Rotation	30.00	77.73	18.00	121.00	25.88
Non-Preferred Shoulder Mobility	30.00	2.40	1.00	3.00	0.77
Preferred Shoulder Mobility	31.00	2.45	1.00	3.00	0.72
Dips	23.00	33.48	7.00	99.00	21.49
Non-Preferred Grip Strength	29.00	26.00	8.00	40.00	7.68
Preferred Grip Strength	29.00	29.00	15.00	44.00	9.14
Sorenson Test	13.00	47.31	3.00	93.00	35.86
Abdominal Strength	19.00	1.74	1.00	4.00	1.10

Table 4: Correlations Shot put F55-F58

CORRELATIONS SHOTPUT F55-F58 (PERFORMANCE TO FITNESS TESTS				
	N	R	R*R	P
Performance Distance	31.00	1.00	1.00	
Technique	20.00	0.52*	0.27	0.02
Sitting height	31.00	0.55*	0.30	0.00
Weight	31.00	0.23	0.05	0.22
Sum of Skinfolds	31.00	0.28	0.08	0.13
Estimated 1 Repetition Maximum Bench Press	28.00	0.63*	0.40	0.00
Non-Preferred Shoulder Flexion	27.00	0.60*	0.36	0.00
Preferred Shoulder Flexion	27.00	0.66*	0.44	0.00
Non-Preferred Shoulder Abduction	28.00	0.67*	0.44	0.00
Preferred Shoulder Abduction	28.00	0.59*	0.34	0.00
Basketball Chest ass	31.00	0.66*	0.44	0.00
Basketball Overhead Pass	31.00	0.65*	0.43	0.00
Non-Preferred Shoulder Internal Rotation	29.00	0.22	0.05	0.25
Preferred Shoulder Internal Rotation	30.00	0.07	0.00	0.72
Non-Preferred Shoulder External Rotation	30.00	0.30	0.09	0.11
Preferred Shoulder External Rotation	30.00	0.26	0.07	0.16
Non-Preferred Shoulder Mobility	30.00	0.13	0.02	0.48
Preferred Shoulder Mobility	31.00	0.05	0.00	0.80
Dips	23.00	0.38	0.14	0.08
Non-Preferred Grip Strength	29.00	0.74*	0.55	0.00
Preferred Grip Strength	29.00	0.82*	0.67	0.00
Sorenson Test	13.00	0.14	0.02	0.66
Abdominal Strength	19	0.029	0.001	0.906

* = P<0.05

Table 5: Descriptive Analyses Shot put F33-F34

Descriptive Statistics	SHOT PUT F33-F34				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Performance Distance	11.00	3.80	2.50	5.31	1.02
Technique	9.00	2.50	1.50	3.00	0.56
Sitting Height	11.00	82.29	76.00	90.20	4.50
Weight	11.00	62.21	47.00	78.00	9.91
Sum of Skinfolds	11.00	35.06	11.00	52.00	14.59
Non-Preferred Shoulder Flexion	10.00	5.10	3.50	8.50	1.54
Preferred Shoulder Flexion	10.00	5.05	2.00	10.00	2.28
Non-Preferred Shoulder Abduction	9.00	5.00	2.00	10.00	2.46
Preferred Shoulder Abduction	11.00	5.59	3.50	10.00	2.05
Basketball Chest Pass	10.00	4.70	1.90	8.00	1.81
Basketball Overhead Pass	10.00	4.12	3.20	5.80	0.99
Non-Preferred Shoulder Internal Rotation	10.00	36.30	12.00	56.00	14.47
Preferred Shoulder Internal Rotation	10.00	50.30	25.00	84.00	21.43
Non-Preferred Shoulder External Rotation	10.00	59.70	7.00	91.00	26.62
Preferred Shoulder External Rotation	10.00	80.10	56.00	103.00	15.57
Non-Preferred Shoulder Mobility	8.00	2.00	1.00	3.00	0.76
Preferred Shoulder Mobility	8.00	1.88	1.00	3.00	0.64
Non Preferred Grip Strength	10.00	19.95	2.00	45.00	12.94
Preferred Grip Strength	11.00	26.00	17.00	44.00	8.96

Table 6: Correlations Shot put F33-F34

CORRELATIONS SHOT PUT F33-F34 PERFORMANCE TO FITNESS TESTS				
	N	R	R*R	P
Performance Distance	11.00	1.00	1.00	
Technique	9.00	0.30	0.09	0.43
Sitting Height	11.00	0.44	0.20	0.17
Weight	11.00	0.07	0.00	0.85
Sum of Skinfolds	11.00	0.50	0.25	0.12
Non-Preferred Shoulder Flexion	10.00	0.60	0.35	0.07
Preferred Shoulder Flexion	10.00	0.48	0.23	0.17
Non-Preferred Shoulder Abduction	9.00	0.49	0.24	0.18
Preferred Shoulder Abduction	11.00	0.54	0.29	0.09
Basketball Chest Pass	10.00	0.64*	0.41	0.05
Basketball Overhead Pass	10.00	0.54	0.29	0.11
Non-Preferred Shoulder Internal Rotation	10.00	0.09	0.01	0.81
Preferred Shoulder Internal Rotation	10.00	0.03	0.00	0.93
Non-Preferred Shoulder External Rotation	10.00	0.27	0.07	0.45
Preferred Shoulder External Rotation	10.00	0.27	0.07	0.46
Non-Preferred Shoulder Mobility	8.00	0.24	0.06	0.57
Preferred Shoulder Mobility	8.00	0.18	0.03	0.67
Non Preferred Grip Strength	10.00	0.51	0.26	0.13
Preferred Grip Strength	11.00	0.66*	0.44	0.03

* = $P<0.05$

Table 7: Descriptive analyses Discus F52-F54

Descriptive Statistics	DISCUS F52-F54				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Performance Distance	10.00	9.71	6.46	14.43	2.62
Technique	6.00	2.33	1.50	3.00	0.61
Sitting Height	10.00	77.37	70.05	87.00	6.14
Weight	10.00	61.15	48.00	105.40	16.25
Sum of Skinfolds	10.00	46.11	18.20	93.80	26.13
Estimated 1RM	9.00	36.44	16.00	60.00	15.68
Non Preferred Shoulder Flexion	9.00	4.11	3.50	4.50	0.49
Preferred Shoulder Flexion	9.00	4.17	3.50	6.00	0.83
Non-Preferred Shoulder Abduction	9.00	4.39	3.50	6.00	0.74
Preferred Shoulder Abduction	9.00	4.64	3.50	6.00	0.89
Basketball Chest Pass	10.00	5.59	3.80	9.50	1.87
Basketball Overhead Pass	10.00	5.26	3.40	7.70	1.34
Non-Preferred Shoulder Internal rotation	10.00	51.60	41.00	72.00	10.01
Preferred Shoulder Internal rotation	10.00	62.50	47.00	102.00	16.22
Non-Preferred shoulder external rotation	10.00	80.40	58.00	114.00	15.80
Preferred Shoulder External Rotation	10.00	85.80	72.00	116.00	11.80
Non-Preferred Shoulder Mobility	10.00	2.60	1.00	3.00	0.70
Preferred Shoulder mobility	10.00	2.70	1.00	3.00	0.67
Non-Preferred Grip Strength	9.00	25.11	16.00	37.00	6.99
Preferred Grip Strength	9.00	25.44	17.00	40.00	6.64

Table 8: Correlations Discus F52-F54

CORRELATION DISCUS F52-F54 PERFORMANCE TO FITNESS TESTS				
	N	R	R*R	P
Performance Distance	10.00	0.71	0.51	
Technique	6.00	0.71	0.51	0.11
Sitting Height	10.00	0.39	0.15	0.26
Weight	10.00	0.02	0.00	0.97
Sum of Skinfolds	10.00	0.25	0.06	0.49
Estimated 1RM	9.00	0.35	0.12	0.36
Non Preferred Shoulder Flexion	9.00	0.11	0.01	0.77
Preferred Shoulder Flexion	9.00	0.13	0.02	0.73
Non-Preferred Shoulder Abduction	9.00	0.53	0.28	0.14
Preferred Shoulder Abduction	9.00	0.54	0.29	0.14
Basketball Chest Pass	10.00	0.67*	0.45	0.03
Basketball Overhead Pass	10.00	0.84*	0.71	0.00
Non-Preferred Shoulder Internal rotation	10.00	0.34	0.12	0.33
Preferred Shoulder Internal rotation	10.00	0.04	0.00	0.92
Non-Preferred shoulder external rotation	10.00	0.28	0.08	0.44
Preferred Shoulder External Rotation	10.00	0.42	0.17	0.23
Non-Preferred Shoulder Mobility	10.00	0.30	0.09	0.39
Preferred Shoulder mobility	10.00	0.28	0.08	0.43
Non-Preferred Grip Strength	9.00	0.34	0.12	0.37
Preferred Grip Strength	9.00	0.52	0.27	0.16

* =P<0.05

Table 9: Descriptive analyses Discus F55-F58

Descriptive Statistics	DISCUS F55-F58				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Performance Distance	35.00	12.36	6.69	20.88	3.24
Technique	24.00	2.50	1.00	4.00	0.74
Sitting Height	35.00	79.32	61.00	94.00	6.16
Weight	35.00	51.68	32.30	83.10	11.35
Sum of Skinfolds	35.00	27.75	10.90	73.20	16.76
Estimated 1 Repetition Maximum Bench Press	33.00	51.70	24.00	78.00	16.26
Non-Preferred Shoulder Flexion	32.00	5.20	2.00	8.50	1.55
Preferred Shoulder Flexion	33.00	5.23	3.25	8.50	1.41
Non-Preferred Shoulder Abduction	32.00	5.10	2.00	8.50	1.55
Preferred Shoulder Abduction	33.00	5.62	3.25	8.50	1.65
Basketball Chest ass	35.00	6.29	3.70	9.10	1.42
Basketball Overhead Pass	35.00	5.48	3.20	8.70	1.08
Non-Preferred Shoulder Internal Rotation	34.00	49.88	15.00	85.00	22.09
Preferred Shoulder Internal Rotation	34.00	61.00	15.00	99.99	23.73
Non-Preferred Shoulder External Rotation	34.00	72.29	14.00	119.00	24.57
Preferred Shoulder External Rotation	34.00	81.47	18.00	121.00	23.87
Non-Preferred Shoulder Mobility	34.00	2.38	1.00	3.00	0.74
Preferred Shoulder Mobility	35.00	2.43	1.00	3.00	0.70
Dips	28.00	31.50	8.00	99.00	18.84
Non-Preferred Grip Strength	34.00	25.75	4.00	41.00	8.53
Preferred Grip Strength	34.00	27.84	4.00	44.00	9.69
Sorenson Test	16.00	40.50	3.00	86.00	31.46
Abdominal Strength	23.00	1.52	1.00	4.00	0.95

Table 10: Correlations Discus F55-F58

CORRELATIONS DISCUS F55-F58 PERFORMANCE TO FITNESS TESTS				
	N	R	R*R	P
Performance Distance	35.00	1.00	1.00	
Technique	24.00	0.34	0.12	0.10
Sitting Height	35.00	0.64*	0.41	0.00
Weight	35.00	0.30	0.09	0.08
Sum of Skinfolds	35.00	0.35*	0.12	0.04
Estimated 1 Repetition Maximum Bench Press	33.00	0.61*	0.38	0.00
Non-Preferred Shoulder Flexion	32.00	0.55*	0.31	0.00
Preferred Shoulder Flexion	33.00	0.56*	0.31	0.00
Non-Preferred Shoulder Abduction	32.00	0.57*	0.33	0.00
Preferred Shoulder Abduction	33.00	0.64*	0.41	0.00
Basketball Chest ass	35.00	0.78*	0.60	0.00
Basketball Overhead Pass	35.00	0.80*	0.63	0.00
Non-Preferred Shoulder Internal Rotation	34.00	0.14	0.02	0.44
Preferred Shoulder Internal Rotation	34.00	0.20	0.04	0.25
Non-Preferred Shoulder External Rotation	34.00	0.23	0.05	0.19
Preferred Shoulder External Rotation	34.00	0.08	0.01	0.64
Non-Preferred Shoulder Mobility	34.00	0.04	0.00	0.83
Preferred Shoulder Mobility	35.00	0.08	0.01	0.65
Dips	28.00	0.27	0.07	0.17
Non-Preferred Grip Strength	34.00	0.58*	0.34	0.00
Preferred Grip Strength	34.00	0.618	0.37	0.00
Sorenson Test	16.00	0.25	0.06	0.35
Abdominal Strength	23.00	0.17	0.03	0.45

* = $P<0.05$

Table 11: Descriptive analyses F33-F34 Discus

Descriptive Statistics	DISCUS F33-F34				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Performance Distance	10.00	9.77	5.26	14.31	3.28
Technique	6.00	2.08	1.00	3.00	0.66
Sitting Height	10.00	82.20	76.00	90.50	4.64
Weight	10.00	61.37	47.00	78.00	9.23
Sum of Skinfolds	10.00	31.84	11.00	51.20	15.27
Non-Preferred Shoulder Flexion	10.00	5.13	3.50	7.25	1.29
Preferred Shoulder Flexion	9.00	5.08	2.00	7.50	1.78
Non-Preferred Shoulder Abduction	9.00	5.00	2.00	7.50	1.89
Preferred Shoulder Abduction	10.00	5.70	3.50	8.50	1.51
Basketball Chest Pass	9.00	5.20	3.80	8.00	1.51
Basketball Overhead Pass	9.00	4.55	3.29	6.90	1.25
Non-Preferred Shoulder Internal Rotation	9.00	40.67	12.00	73.00	18.75
Preferred Shoulder Internal Rotation	9.00	54.11	25.00	85.00	24.91
Non-Preferred Shoulder External Rotation	9.00	64.89	7.00	101.00	29.28
Preferred Shoulder External Rotation	9.00	80.67	56.00	104.00	17.44
Non-Preferred Shoulder Mobility	8.00	1.88	1.00	3.00	0.83
Preferred Shoulder Mobility	8.00	1.75	1.00	3.00	0.71
Non Preferred Grip Strength	9.00	23.72	2.00	40.00	12.41
Preferred Grip Strength	10.00	28.20	17.00	40.00	8.63

Table 12: Correlations F33-F34 Discus

CORRELATIONS DISCUS F33-F34 PERFORMANCE TO FITNESS TESTS				
	N	R	R*R	P
Performance Distance	10.00	1.00	1.00	
Technique	6.00	0.93*	0.87	0.01
Sitting Height	10.00	0.60	0.36	0.07
Weight	10.00	0.41	0.17	0.24
Sum of Skinfolds	10.00	0.84*	0.71	0.00
Non-Preferred Shoulder Flexion	10.00	0.45	0.20	0.22
Preferred Shoulder Flexion	9.00	0.45	0.21	0.21
Non-Preferred Shoulder Abduction	9.00	0.36	0.13	0.35
Preferred Shoulder Abduction	10.00	0.29	0.08	0.42
Basketball Chest Pass	9.00	0.86*	0.73	0.00
Basketball Overhead Pass	9.00	0.85*	0.73	0.00
Non-Preferred Shoulder Internal Rotation	9.00	0.00	0.00	1.00
Preferred Shoulder Internal Rotation	9.00	0.10	0.01	0.80
Non-Preferred Shoulder External Rotation	9.00	0.14	0.02	0.72
Preferred Shoulder External Rotation	9.00	0.36	0.13	0.35
Non-Preferred Shoulder Mobility	8.00	0.38	0.15	0.35
Preferred Shoulder Mobility	8.00	0.25	0.06	0.53
Non Preferred Grip Strength	9.00	0.66	0.44	0.05
Preferred Grip Strength	10.00	0.70*	0.49	0.03

* = $P<0.05$

Table 13: Descriptive Analyses Javelin F52-F54

Descriptive Statistics	JAVELIN F52-F54				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Performance Distance	12.00	9.81	5.42	17.59	3.95
Technique	8.00	2.19	1.50	3.00	0.53
Sitting Height	12.00	82.17	70.00	98.00	9.05
Weight	12.00	69.60	34.50	119.65	27.39
Sum of Skinfolds	12.00	43.73	18.20	93.80	23.91
Estimated 1RM	11.00	44.18	16.00	84.00	24.21
Non Preferred Shoulder Flexion	11.00	5.23	3.50	10.00	2.47
Preferred Shoulder Flexion	11.00	5.09	3.50	10.00	2.47
Non-Preferred Shoulder Abduction	11.00	5.82	3.50	14.00	3.30
Preferred Shoulder Abduction	11.00	5.89	3.50	14.00	3.27
Basketball Chest Pass	12.00	6.18	3.80	9.80	2.42
Basketball Overhead Pass	12.00	5.73	3.40	9.80	1.99
Non-Preferred Shoulder Internal rotation	12.00	52.75	26.00	88.00	15.72
Preferred Shoulder Internal rotation	12.00	61.92	39.00	88.00	13.09
Non-Preferred shoulder external rotation	12.00	83.17	65.00	114.00	13.88
Preferred Shoulder External Rotation	12.00	87.42	70.00	116.00	11.68
Non-Preferred Shoulder Mobility	12.00	2.58	1.00	3.00	0.67
Preferred Shoulder mobility	12.00	2.67	1.00	3.00	0.65
Non-Preferred Grip Strength	10.00	29.80	16.00	61.00	14.75
Preferred Grip Strength	11.00	28.18	5.00	63.00	16.42

Table 14: Correlations F52-F54 Javelin

CORRELATION JAVELIN F52-F54 PERFORMANCE TO FITNESS TESTS				
	N	R	R*R	P
Performance Distance	12.00	1.00	1.00	
Technique	8.00	0.80*	0.64	0.02
Sitting Height	12.00	0.39	0.16	0.21
Weight	12.00	0.35	0.12	0.27
Sum of Skinfolds	12.00	0.04	0.00	0.91
Estimated 1RM	11.00	0.76*	0.58	0.01
Non Preferred Shoulder Flexion	11.00	0.73*	0.53	0.11
Preferred Shoulder Flexion	11.00	0.74*	0.55	0.01
Non-Preferred Shoulder Abduction	11.00	0.69*	0.47	0.02
Preferred Shoulder Abduction	11.00	0.70*	0.49	0.02
Basketball Chest Pass	12.00	0.71*	0.51	0.01
Basketball Overhead Pass	12.00	0.83*	0.69	0.00
Non-Preferred Shoulder Internal rotation	12.00	0.16	0.03	0.61
Preferred Shoulder Internal rotation	12.00	0.28	0.08	0.38
Non-Preferred shoulder external rotation	12.00	0.38	0.15	0.22
Preferred Shoulder External Rotation	12.00	0.39	0.15	0.21
Non-Preferred Shoulder Mobility	12.00	0.54	0.29	0.07
Preferred Shoulder mobility	12.00	0.61*	0.37	0.04
Non-Preferred Grip Strength	10.00	0.82*	0.67	0.00
Preferred Grip Strength	11.00	0.77*	0.59	0.01

* = $P<0.05$

Table 15: Descriptive analyses F55-F58 Javelin

Descriptive Statistics	JAVELIN F55-F58				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Performance Distance	23.00	11.99	6.98	22.23	3.54
Technique	7.00	2.36	2.00	3.00	0.48
Sitting Height	24.00	79.83	74.00	94.00	5.24
Weight	24.00	54.93	40.00	83.10	11.81
Sum of Skinfolds	24.00	30.23	7.10	77.10	18.11
Estimated 1 Repetition Maximum Bench Press	23.00	51.39	24.00	76.00	16.04
Non-Preferred Shoulder Flexion	23.00	5.35	2.00	8.50	1.61
Preferred Shoulder Flexion	23.00	5.48	3.50	8.50	1.56
Non-Preferred Shoulder Abduction	23.00	5.48	2.00	8.50	1.72
Preferred Shoulder Abduction	23.00	5.85	3.50	8.50	1.77
Basketball Chest ass	24.00	6.24	3.70	8.30	1.29
Basketball Overhead Pass	24.00	5.40	3.20	7.20	0.89
Non-Preferred Shoulder Internal Rotation	24.00	48.71	15.00	85.00	22.59
Preferred Shoulder Internal Rotation	24.00	58.21	15.00	90.00	24.00
Non-Preferred Shoulder External Rotation	24.00	70.33	14.00	119.00	26.94
Preferred Shoulder External Rotation	24.00	83.75	18.00	121.00	25.49
Non-Preferred Shoulder Mobility	24.00	2.58	1.00	3.00	0.58
Preferred Shoulder Mobility	24.00	2.67	1.00	3.00	0.56
Dips	18.00	29.89	8.00	99.00	21.40
Non-Preferred Grip Strength	23.00	26.02	4.00	41.00	10.45
Preferred Grip Strength	23.00	29.41	4.00	44.00	10.73
Sorenson Test	7.00	51.43	12.00	85.00	29.86
Abdominal Strength	16.00	1.56	1.00	4.00	0.96

Table 16: Correlations F55-F58 Javelin

CORRELATIONS JAVELIN F55-F58 PERFORMANCE TO FITNESS TESTS				
	N	R	R*R	P
Performance Distance	23.00	1.00	1.00	
Technique	7.00	0.78*	0.62	0.04
Sitting Height	23.00	0.39	0.15	0.07
Weight	23.00	0.18	0.03	0.42
Sum of Skinfolds	23.00	0.42	0.17	0.05
Estimated 1 Repetition Maximum Bench Press	22.00	0.53*	0.28	0.01
Non-Preferred Shoulder Flexion	22.00	0.36	0.13	0.10
Preferred Shoulder Flexion	22.00	0.36	0.13	0.10
Non-Preferred Shoulder Abduction	22.00	0.41	0.16	0.06
Preferred Shoulder Abduction	22.00	0.57*	0.32	0.01
Basketball Chest ass	23.00	0.62*	0.38	0.00
Basketball Overhead Pass	23.00	0.63*	0.40	0.00
Non-Preferred Shoulder Internal Rotation	23.00	0.54*	0.29	0.01
Preferred Shoulder Internal Rotation	23.00	0.54*	0.29	0.01
Non-Preferred Shoulder External Rotation	23.00	0.54*	0.29	0.01
Preferred Shoulder External Rotation	23.00	0.34	0.12	0.11
Non-Preferred Shoulder Mobility	23.00	0.02	0.00	0.95
Preferred Shoulder Mobility	23.00	0.10	0.01	0.66
Dips	17.00	0.27	0.07	0.30
Non-Preferred Grip Strength	22.00	0.48	0.23	0.02
Preferred Grip Strength	22.00	0.39	0.15	0.07
Sorenson Test	7.00	0.16	0.02	0.74
Abdominal Strength	15.00	0.09	0.01	0.75

* = $P<0.05$

Table 17: Descriptive analyses F33-F34 Javelin

Descriptive Statistics	JAVELIN F33-F34				
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Performance Distance	9.00	8.53	5.48	12.10	2.47
Technique	7.00	2.29	1.50	3.00	0.70
Sitting Height	9.00	83.30	76.00	90.20	4.65
Weight	9.00	62.40	47.00	78.00	10.16
Sum of Skinfolds	9.00	32.01	11.00	52.00	15.94
Non-Preferred Shoulder Flexion	7.00	5.21	3.50	8.50	1.78
Preferred Shoulder Flexion	9.00	5.44	2.00	10.00	2.40
Non-Preferred Shoulder Abduction	7.00	5.64	2.00	10.00	2.64
Preferred Shoulder Abduction	9.00	5.94	3.50	10.00	2.10
Basketball Chest Pass	8.00	5.17	1.90	8.00	1.99
Basketball Overhead Pass	8.00	4.46	3.20	5.80	1.08
Non-Preferred Shoulder Internal Rotation	8.00	41.63	12.00	73.00	19.46
Preferred Shoulder Internal Rotation	8.00	55.38	25.00	85.00	21.28
Non-Preferred Shoulder External Rotation	8.00	53.00	7.00	84.00	25.09
Preferred Shoulder External Rotation	8.00	77.50	56.00	96.00	15.18
Non-Preferred Shoulder Mobility	6.00	2.17	1.00	3.00	0.75
Preferred Shoulder Mobility	6.00	2.00	1.00	3.00	0.63
Non Preferred Grip Strength	8.00	22.31	2.00	45.00	16.23
Preferred Grip Strength	9.00	29.78	18.00	44.00	9.02

Table 18: Correlations F33-F34 Javelin

CORRELATIONS JAVELIN F33-34 PERFORMANCE TO FITNESS TESTS				
	N	R	R*R	P
Performance Distance	9.00	1.00	1.00	
Technique	7.00	0.69	0.47	0.09
Sitting Height	9.00	0.18	0.03	0.65
Weight	9.00	0.44	0.19	0.24
Sum of Skinfolds	9.00	0.65	0.42	0.06
Non-Preferred Shoulder Flexion	7.00	0.69	0.48	0.09
Preferred Shoulder Flexion	9.00	0.70*	0.49	0.04
Non-Preferred Shoulder Abduction	7.00	0.61	0.37	0.15
Preferred Shoulder Abduction	9.00	0.63	0.40	0.07
Basketball Chest Pass	8.00	0.89*	0.78	0.00
Basketball Overhead Pass	8.00	0.84*	0.71	0.01
Non-Preferred Shoulder Internal Rotation	8.00	0.32	0.10	0.44
Preferred Shoulder Internal Rotation	8.00	0.27	0.07	0.52
Non-Preferred Shoulder External Rotation	8.00	0.17	0.03	0.69
Preferred Shoulder External Rotation	8.00	0.48	0.23	0.23
Non-Preferred Shoulder Mobility	6.00	0.77	0.60	0.07
Preferred Shoulder Mobility	6.00	0.72	0.52	0.11
Non Preferred Grip Strength	8.00	0.90*	0.80	0.00
Preferred Grip Strength	9.00	0.75*	0.56	0.02

*=P<0.05

Appendix D

Stellenbosch
SPORT SCIENCE

CONSENT FORM

ATHLETE'S NAME... **AGE**:........................

SPORT:.. **CLASS:**....................

PLEASE READ THE FOLLOWING CAREFULLY:

1. EXPLANATION OF HIGH PERFORMANCE TESTING PROCEDURE.
You will undergo a battery of tests to evaluate various physical and motor components associated with elite performance in your sport. The intensity of these tests will vary from comfortable to strenuous. The exercise tester may terminate testing at any point if s/he seems it necessary or appropriate. You may also stop the testing at **any time** if you feel uncomfortable.

2. RESPONSIBILITIES OF THE PARTICIPANT
Any information you possess about your health status, or previous experiences of unusual feelings with physical effort, may affect the safety and value of the testing procedure. Your prompt reporting of feelings with effort during the test are also of great importance. You are responsible to fully disclose such information.

3. RESULTS
The results from the different testing procedures can reveal some of your physical and motor strengths and weaknesses. In order to permit the tester to formulate a comprehensive programme for improvement, your complete co-operation and compliance is essential.

4. CONFIDENTIALITY
The results from your tests are strictly confidential and only the testing center directly involved in the testing will have access to these records.

I hereby declared that:

- The testing procedures have been explained to me by the tester and I understand them.
- To the best of my knowledge I am currently free from any existing medical condition/other complaint or injury that would preclude me from full participation in the testing.
- I give my written consent to Stellenbosch Sport Science to conduct the battery of tests.
- I indemnify Stellenbosch Sport Science and the Stellenbosch Sport Science testers against any injury, death or damages which might stem from my participation in the testing.
- I give my consent for the results to be used for research purposes.

Sport Science, University of Stellenbosch
Private Bag X1, Matieland, 7602, South Africa
Tel : (021) 808 4719, Fax : (021) 808 4817

Stellenbosch
SPORT SCIENCE

Athlete's signature:.................................. Date:..............................

Guardians signature(if under age of 18)........................... Date:..............................

Tester's signature:.................................... Date:............................

Sport Science, University of Stellenbosch
Private Bag X1, Matieland, 7602, South Africa
Tel : (021) 808 4719, Fax : (021) 808 4817

Appendix E

Stellenbosch
Sport Science

FIELD EVENT – SITTING

April 2001

PERSONAL DETAILS

Surname:	Ferreira	**Date tested:**	14/04/01
Name:	Suzanne	**Age Group:**	Open
Gender:	F	**Province:**	Boland
Class:	F34		

ANTHROPOMETRY

Anthropometry is the science that deals with the measurements of size, weight and proportions of the human body. One of the most important aspects of preparing an athlete for competition is the establishment of an optimal body weight for peak performance.

Test	Score	Rate
Height (cm):	81.50	
Weight (kg):	49.50	
Sum of Skinfolds:	27.80	Below Average

FLEXIBILITY

Flexibility forms an integral part of movement. It is defined as the range of motion of a joint or a related series of joints. Sufficient flexibility is required for more effective muscular contraction, protection and maximal range of motion, which in turn is necessary for peak athletic performance.

Test	Score	Rate	Test	Score	Rate
L Shoulder Internal Rot:	24	Below Average	**R Shoulder Internal Rot:**	26	Below Average
L Shoulder External Rot:	79	Below Average	**R Shoulder External Rot:**	71	Below Average
Shoulder mobility Left:	3	Above Average	**Shoulder mobility Right:**	3	Above Average

STRENGTH

The term muscular strength refers to the capacity of a muscle for active development of tension, irrespective of the specific conditions under which this tension is measured

Test	Score	Rate	Test	Score	Rate
L Shoulder Flexion:	4.5	Average	**R Shoulder Flexion:**	4.5	Average
L Shoulder Abduction	4.5	Average	**R Shoulder Abduction:**	3.5	Below Average
Grip Strength Non Preferred:	19	Below Average	**Grip Strength Preferred:**	20	Below Average
Estimated 1RM Arm Press:	26	Below Average	**Abdominal Strength:**	1	Below Average

POWER

Power is the measurement of the athlete's ability to exert force at high speeds.

Test	Score	Rate	Test	Score	Rate
Basketball Throw Chest	3.90	Below Average	**Basketball Throw Overh ead**	3.50	Below Average

MUSCLE ENDURANCE

Muscle endurance is the ability of a muscle group to repeat the same action over and over again. During this test we ask the athlete to perfom as many sit-ups/push-ups as possible in one minute .

Test	Score	Rate	Test	Score	Rate
Dips:	7	Average	**SorensonTest:**	114	Average

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