THE UTILIZATION OF A CUSTOMISED TRAINING PROGRAMME FOR CLUB LEVEL NETBALL PLAYERS

LINDIE FOURIE

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Study leader: Prof. E. Terblanche

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DECEMBER 2005

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.

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December 2005

ABSTRACT

The purpose of the study was to determine the effect of a customised training programme on the physical components of first league netball players. The key physical variables that affect netball performance were identified as aerobic fitness, anaerobic fitness, power, muscle strength, flexibility, speed, agility, and muscle endurance. The fitness tests and norms used in this study were mainly based on the Australian protocol, "Physiological Tests for the Assessment of Netball Players".

Two netball clubs in the Boland participated in this study. These two teams played in the same netball league, but they were not matched in any other way. The experimental group (n=14) followed the customised training programme, while the control group (n=16) followed their normal training sessions. After baseline testing, the experimental group completed 23 training sessions in which specific aspects of netball fitness were addressed. After 16 weeks, both groups repeated all the tests. Through statistical analysis, the effect of the training programme was determined, and the differences between the experimental and control groups were quantified.

Results of the study revealed the following:

1. The experimental group was statistically significantly better in all the fitness tests during baseline testing, compared to the control group.
2. Power improved significantly through this customised training programme.
3. Although only a few variables changed significantly after the training programme, the experimental group did perform better in most fitness tests after the programme.

This study shows that a customised training programme has the potential to improve certain aspects of a netball player's fitness. The programme should, however, be longer and more sport-specific to produce the desired results. Top netball players should rely on not only their netball skills to be successful, but should also develop their physical capacities optimally.

OPSOMMING

Die doel van die studie was om die effek van ‘n doelgemaakte inoefeningsprogram op die fisieke komponente vir eerste liga netbalspelers te ondersoek. Die fisieke veranderlikes wat netbal prestasie kan beïnvloed is geïdentifiseer as aërobiese fiksheid, anaërobiese fiksheid, plofkrag, spierkrag, lenigheid, spoed, ratsheid, en spieruithouvermoë. Die fiksheidstoetse en norms wat in hierdie studie gebruik is, is gebaseer op die Australiese protokol, “Physiological Tests for the Assessment of Netball Players”.

Twee netbalklubs in die Boland het aan die studie deelgeneem. Hoewel hierdie spanne in dieselfde liga deelgeneem het, was hulle op geen ander manier afgepaar nie. Die eksperimentele groep (n=14) het die doelgemaakte inoefeningsprogram gevolg, terwyl die kontrole groep (n=16) hul normale oefensessies gevolg het. Na afloop van die basislyn toetse, het die eksperimentele groep 23 oefensessies voltooi waarin aandag gegee is aan spesifieke aspekte van netbal fiksheid. Na 16 weke het beide groepe die toetse herhaal. Met behulp van statistiese analise is die effek van die inoefeningsprogram geëvalueer en die verskille tussen die eksperimentele en kontrole groepe is gekwantifiseer.

Die resultate het die volgende gewys:

1. Die eksperimentele groep het statisties betekenisvol beter gevaar as die kontrole groep in al die fiksheidstoetse tydens die basislyn opname.
2. Plofkrag het beduidend verbeter deur die doelgemaakte inoefeningsprogram.
3. Hoewel enkele veranderlikes ‘n statisties beduidende verskil gewys het, het die eksperimentele groep in die meeste fiksheidstoetse beter gevaar na die inoefeningsprogram.

Hierdie studie wys dat ‘n doelgemaakte inoefeningsprogram die potensiaal het om sekere aspekte van ‘n netbalspeler se fiksheid te verbeter. Die program behoort egter langer en meer sport-spesifiek te wees om die beste resultate te lewer. Top netbalspelers behoort dus nie net op hul netbal vaardighede staat te maak om sukses te behaal nie, maar behoort ook hulle fisieke kapasiteit optimaal te ontwikkel.

“Every person has a story to tell, it’s not important how you tell your story but how you live it is what makes the difference”

This is for you LORD

and

Maties Netball 5&6 2004

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Chapter One

Setting the Problem

According to Wallace (2002), the game of netball started in the early 1890's when a physical education teacher in Sweden (University of Greenwich), used wastepaper baskets as the rings. Their basic rules were more or less the same as the rules of today's game. Netball, at the top level, is a fast-paced and highly competitive team sport. It is also one of the most popular sports in South Africa, in which people of all ages and levels of ability participate.

A coach cannot provide training to prepare players for all possible game situations, however, by carefully examining the demands of netball participation, he/she can provide training that will prepare the players to meet many of the physical challenges that must be met throughout a game. Netball is an explosive sport, where a player must be physically prepared for many catches, passes, jumps, accelerations and changes of direction, during the game. In addition to mastering these skills, a successful netball player will need different physical capabilities to support these skills, such as, speed, agility, and endurance (Bell et al. 1994), as well as aerobic and anaerobic power (Bell et al. 1994; Hawley & Burke, 1998; Ellis & Smith, 2000; Uys, 2001). Each of these physical components of performance can be trained and improved individually, or developed together.

Purpose of the Study

The purpose of the study was to determine the effect of a customised training programme on the physical components of performance of first league netball players. The key physical variables that affect netball performance were identified as aerobic fitness, anaerobic fitness, power, strength, flexibility, speed, agility and muscle endurance (Ellis & Smith, 2000). Although perceptual and motor skills, as well as psychological (i.e., pressure in a game situation) and genetic factors (i.e., physical height and weight)

can influence the performance of a player and may also be of vital importance, the focus of this study was on the physical components only.

This study represents a starting point for not only the study of customised training of netball players, but also provides information about netball players engaged in a netball-specific fitness testing protocol. According to Ferreira (2001:3) "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

Sport is recognized as an important force in society. "Sport has the ability to build a nation," as President Nelson Mandela once said. Sport also can have an important role in the lives of individuals.

It can take a lifetime to get to know someone
to the same extent that you get to know someone
in one hour of playing a sport together.

Unknown Author

In order for any sport to reach its potential to contribute to social or individual development, it must be properly learned and properly played. For a coach, knowledge of how to teach the basic netball skills (landing, pivoting and changing direction, stopping, throwing, catching and shooting) is critical. It is equally important to learn how to train the physical components of the game, which include aerobic fitness, anaerobic fitness, power, strength, flexibility, speed, agility and muscle endurance.

This study utilized an approach called "customised training" as a method to improve the physical attributes of netball that will help players to improve their performance on the court. This approach involves the use of a sport-specific testing protocol to identify the strengths and weaknesses of players.

A training programme was then customised to address the weaknesses. The results of the pre-tests were compared to the post-tests to determine the effects of the programme. The results of this study will not only contribute to an understanding of how customised training can support netball performance, but it will also expand our understanding of the physical components of netball, and thus contribute to more sport-specific testing and training in the future.

Research Question

The following research question was used to guide the study.

1. What is the effect of a customised training programme on the physical fitness of club level netball players? Physical fitness was defined by the following variables:

    a. Aerobic fitness

    b. Anaerobic fitness

    c. Power

    d. Strength

    e. Flexibility

    f. Speed

    g. Agility

    h. Muscle endurance

Definitions

Customised training

Customised training was defined as the specific training of a group of athletes on the basis of their strengths and weaknesses related to netball sport performance.

Physical fitness components

Physical fitness components are the physical capabilities that affect the performance of an athlete in his/her sport. For example, in netball, the physical fitness components are aerobic fitness, anaerobic fitness, power, strength, flexibility, speed, agility and muscle endurance (Ellis & Smith, 2000).

Performance profile

A performance profile is a visual representation of the data gathered from testing, usually taking the form of a histogram (Vincent, 1999). Butler (1996) has also recommended a more complex use of performance profiles by sport psychologists, who will ask coaches and players to create profiles of their personal perceptions on certain situations. A comparison can then be made between the coach's perception and the player's perceptions. In this study, the more straightforward use of profiles to represent the outcomes of testing was used.

Limitations

The following factors may have had an impact on the results of this study:

1. Many of the players in both the experimental and control groups had little previous experience with physical fitness testing. It is possible that some players did not give a 100% effort with each test, as they were not fully aware of what was expected of them.

2. Although the sample size was sufficient at the start of the study, many players (especially in the control group) did not complete the post-tests. This may have contributed to the non-significant results.

3. The number of training sessions available for the customised programme was limited to the existing practice schedule of the experimental group, which was not under control of the investigator. The lack of improvement in some physical performance measures may actually be as a result of too few training sessions and not because of the customised training programme per se.

4. According to the baseline test results, the experimental group scored better in many of the tests than the control group. This may have resulted in minimal changes in the experimental group, while the control group improved due to regular training.

5. The experimental and control groups were not matched prior to the study.

6. The physical fitness tests used in this study are general fitness tests for which norms were available. The reliability and validity of these tests for scientific purposes have not been determined yet.

Summary

This study explores the potential of a customised training programme to improve the physical fitness components of first league netball players. The results of the physical pre- and post-tests were compared in the format of physical performance profiles, in order to determine the degree of improvement in physical fitness.

Chapter Two

A Review of the Literature

Netball is a fast-paced team sport that requires good levels of skill, speed, agility and endurance (Bell et al., 1994). Each of these components can be trained and improved individually or in combination with each other. Netball is also an explosive sport, where a player must be physically prepared for many catches, passes, jumps, accelerations and changes of direction during a game. A typical game is characterised by repetitive bursts of high intensity play, interrupted by periods of lower intensity play (Bell et al. 1994; Hawley & Burke, 1998; Ellis & Smith, 2000; Uys, 2001). Therefore, netball players require high levels of both aerobic and anaerobic power. The specific physical and physiological requirements of players will vary somewhat according to playing position, due to variations in activity patterns of individuals during a game (Ellis & Smith, 2000). In fact, factors such as fitness levels and skill may influence a player's performance in a specific playing position. However, the total fitness of the whole team becomes increasingly important at the higher levels of competition. To be successful as a team, all players must possess excellent explosive muscle power, muscular strength and endurance, speed, agility and flexibility.

Physical Variables Relevant to Netball

Although perceptual and motor skills, as well as psychological skills and genetic factors are of vital importance, because they influence the performance of every player, this study focused only on the physical components of netball performance.

Aerobic Fitness

Bunc (1994) described aerobic fitness as the "frequently most important aspect of physical fitness", and one that must be regarded differently for men and women, as well as differing ages and levels of training. He defined aerobic fitness as:

> …the ability to maintain the various processes involved in metabolic exchange as close to the resting state as is mutually possible during the performance of a strenuous and fully learnt task for a moderate time, with a capacity to reach a higher steady rate of working than the unfit and to restore promptly after exercise all equilibria which were disturbed (p.159).

Chandler (1994:11) defined aerobic fitness in a physiological sense as "the ability of the athlete to take in, transport, and use oxygen".

A high level of aerobic fitness will enable a netball player to practice and play for longer time periods and at higher intensities (Ellis & Smith, 2000). Bishop (2001) confirmed this by emphasising that in most team sports (such as netball), a high level of aerobic fitness is important for recovery during short periods of rest, as well as to maintain a high standard of play throughout the game. As a team sport, netball requires a few repeated high intensity efforts of a minute or longer which give an endurance component to the sport (Unknown author, Sports Coach, Winter 2000).

Maximal Oxygen Consumption

Chandler (1994) identified the maximum oxygen uptake (VO_{2max}) of an individual as the test which best measures aerobic fitness. This was supported by both Baquet et al. (2003) and Sproule et al. (1993). Maximum oxygen uptake (VO_{2max}) reflects the maximal rate of aerobic energy expenditure (Jones & Carter, 2000). Grant et al. (1995:147) defined maximum oxygen consumption as "the maximum rate at which oxygen can be consumed" and as a measurement commonly used to assess aerobic fitness. Rowland (1996:77) described VO_{2max} as a "reproducible value that provides a numerical indicator of a subject's level of aerobic fitness". According to Mayhew et al. (1994) maximum oxygen consumption has been accepted as the preferred measurement for the evaluation aerobic power. This was confirmed by Chandler (1997) and Grant et al. (1999).

Chandler (1994), however, cautioned that VO_{2max} may not be the sole determinant of actual aerobic fitness. According to Bunc (1994), a high VO_{2max} value does not necessarily translate to good physical performance on the court, since many other factors, such as technique and psychological factors, will also influence game performance.

Maximum oxygen consumption is important for netball players because it establishes the upper limit of the player's ability to produce energy through oxidative pathways (Sinnett et al. 2001), thereby enabling the player to maintain relatively high levels of activity for prolonged periods of time.

Assessment of Aerobic Fitness

Aerobic fitness is crucial for netball players because it supports performance during prolonged, higher intensity activities for a team which in netball is usually more than ten minutes altogether (Ellis & Smith, 2000). Ellis & Smith (2000) also found that the estimated VO_{2max} for netball players ranged from:

- 41-57 $ml.kg^{-1}.min^{-1}$ (mean of 49.3) for South Australian Sports Institute players (1995).
- 44-59 $ml.kg^{-1}.min^{-1}$ (mean of 50.6) for Australian Open netball players (1997).
- 40-62 $ml.kg^{-1}.min^{-1}$ (mean of 50.8) for Australian Institute of Sport U/21 players (1997).

VO_{2max} is typically measured through open-circuit spirometry using sophisticated metabolic systems. According to the literature, the most appropriate VO_{2max} test for netball is the treadmill test. Although the direct measurement of VO_{2max} through gas analysis is an accurate and reliable method to determine aerobic capacity, it is not always a practical test for field studies (Baquet et al. 2003).

According to Grant et al. (1999) numerous indirect methods have been developed as field tests for estimating VO_{2max}. An example of such a test is the widely accepted Multistage Fitness Test, popularly known as the "Bleep Test" (Grant et al. 1995).

Benefits of the Multistage Fitness Test include that it is affordable and it can cater for large numbers of subjects who can perform the test at the same time.

Training to Improve Aerobic Fitness

Maximal oxygen consumption can be improved by endurance activities such as jogging long distances. Rowland (1996) stated that generally a close relationship is observed between performance in endurance activities and VO_{2max}.

Aerobic fitness for team sports can also be develop through interval training. Bishop (2001) described interval training as "involving repeated periods of higher intensity exercise interspersed with periods of easier exercise" (p.27), while the recovery time is equal to or shorter than the work bouts to follow. Brandon (2004) stated that interval training is a well-known method for improving aerobic fitness. He continued by saying that this training allows athletes to cover more distance at a high intensity than they could have with continuous training. Because interval training is of a high intensity, it is a valuable method to improve both aerobic and anaerobic fitness.

Brandon (2004) studied the effect of a 6 week interval training programme on the aerobic fitness of general athletes divided into two randomly selected groups. One group followed an interval training programme, while the other group continued doing their usual weekly training programme. There was a statistically significant improvement in $VO_{2\ max}$ (13%) of the experimental group, showing that interval training successfully increases aerobic fitness. Therefore the interval training allows them to develop higher $VO_{2\ max}$ values.

According to Koziris et al. (1996), one should not only train aerobically when training for an endurance type activity (such as netball). Even for anaerobic activities, such as 100m sprint, where aerobic power is used to a lesser extent, it is important to train both aerobic and anaerobic capacity because these two variables function in a complementary relationship. The dominant variable of the two will depend on the demands of a particular sport. In netball, anaerobic fitness is often considered more important.

Anaerobic Fitness

Baker et al. (1993) explained that anaerobic fitness is the ability to perform short, high intensity activities (i.e., 100m sprint), and that it relies primarily on the immediate energy provided by ATP (adenosine triphosphate) and CP (creatine phosphate). According to Daniels (2001), all athletes rely heavily on anaerobic energy production at the onset of an exercise bout, or at the conclusion of an event.

Assessment of Anaerobic Fitness

Although the assessment of anaerobic fitness is usually more difficult than the determination of aerobic fitness, the Wingate (30sec) test is a recognized (reliable and valid) laboratory test for anaerobic capacity. The disadvantage of the Wingate test is that expensive, sophisticated equipment is needed and that the test is time-consuming, since athletes must be tested individually.

According to Rowland (1996), there are short-duration field tests that also accurately measure anaerobic fitness. The Repeated Sprint-Ability test is one such test and was used in this research. The disadvantage of the Repeated Sprint-Ability test is that it has not been compared to the Wingate test yet to confirm its validity and reliability to test anaerobic fitness.

Training to Improve Anaerobic Fitness

In netball, short bursts of exercises are performed when competing. Therefore, the improvement of anaerobic fitness in netball players should make a difference to their overall performance. However, no research was found regarding the anaerobic fitness levels of netball players, or the effect of specific training to improve this aspect.

Anaerobic fitness can be trained with continues short bursts of intense training (i.e. running lines across the court). Usually short rest periods are allowed for recovery and multiple repetitions are suggested to obtain optimal benefits.

Power

Ferreira (2001:47) defined power as "the ability to generate force and a factor that is highly related to successful performance in many sports". Wilmore and Costill (1993) defined power as the product of strength and speed, which is why it is not always identified as a separate component of physical fitness. Power is the ability of an athlete to convert strength into optimal distance, height or speed. Power is also defined as the amount of work done in a certain period of time. Therefore, the faster a movement is executed, the greater the power (Yessis, 1994). Power can also be considered as the capacity to do a given amount of work as rapidly as possible.

When trying to understand the concept power, the following formula is usually presented: P=(F x D)÷ t where *F* is the application of force, *d* the application through the greatest distance and *t* the application through the least amount of time. Coaches recognise that it requires greater strength to apply greater force, and a reduction in the time of movement is needed to increase speed (Radcliffe, 1994).

Power is important for netball players because the majority of any sporting action requires muscular power. Virtually all activities depend on the ability of the muscles to generate force and to develop strength and power. Power is often associated with explosiveness, and therefore jumping ability working together with other speed, agility and acceleration may contribute to a netball player's level of success within game situations.

Assessment of Power

Leg power is crucial for netball players and relatively easy to measure with the vertical jump test (Ellis & Smith, 2000). The vertical jump test is widely used to measure explosive leg power and jumping ability (Pyne, 2002). Keir et al. (2003) stated that the vertical jump is important for sports where jumping height is critical for success. Vertical jumping ability is often what sets apart athletes from each other (Baker, 1996). Besides the obvious need for leg and hip strength and/or power, an equally important physical component for success in women sports, such as netball, is upper body strength.

Howell et al. (2001) confirmed that a combination of lower- and upper-body strength and power are required for successful participation in sports.

Substantial sport-specific and normative data are available for vertical jump tests. Ellis & Smith (2000) reported the following values for the vertical jump:

- 42.6 cm for South Australian Sports Institute netball players (1995).
- 53.4 cm for Australian Open netball players (1997).
- 49 cm for Australian Institute of Sport U/21 netball players (1997).

According to unpublished data from the South African national netball team, the average score for the vertical jump was 44 cm in 2001, and 42 cm in 2002 (South African Sports Commission, 2002).

Training to Improve Power

Power can be trained with any jumping activity (such as tuck jumps). Any activity where strength and speed are required in combination, should successfully increase power.

Strength

Dynamic strength is defined as the maximal ability of a muscle to exert force at a specific velocity (Kraemer & Newton, 1994). Dynamic strength is required in order for muscles to function for an extended time period against resistance, i.e., to meet the challenge of activities that require muscle endurance.

Strength, as a physical parameter, is difficult to define. The strong runner, the strong thrower, and the strong jumper have different patterns of strength. Ferreira (2001) defined strength as “the amount of force that can be exerted by one group of muscles in a single contraction” (p. 41). Kraemer & Newton (1994) defined dynamic strength as the maximal ability of a muscle to exert force at a specific velocity.

Winch (2004) stated that 'strength' is a generic term, used to describe many dissimilar abilities. He explained that strength actually has five components that can be measured:

1. *Strength-endurance:* the ability to move light resistance for an extended time.

2. *Absolute dynamic strength:* the maximum force a muscle can generate to create movement.

3. *Absolute static strength:* the maximum force a muscle can generate and apply without creating movement.

4. *Reactive strength:* the maximum force a muscle can apply in response to an opposite force.

5. *Power:* the dynamic strength multiplied by the speed it can be applied to.

In netball absolute dynamic strength and power are the two most important strength parameters. Strength is also closely related to muscle endurance. To emphasise this relationship, Ellis & Smith (2000) identified the Seven Stage Abdominal Test as a graded test for abdominal strength.

Assessment of Strength

When testing a netball player's strength, it is particularly important to test the muscles involved with the throwing, jumping and acceleration actions. "The development of strength is crucial for almost all sports for potentially different reasons" (Kraemer & Gómez, 2001). Even small changes in muscle size can make a big difference in strength. For the purpose of this study, the assessment of strength was based on the Seven Stage Abdominal Test. Each stage of this test becomes progressively more difficult as the position of the limbs is changed. The aim of the test is to accomplish as many stages as possible. In this situation, core strength is tested (Ellis et al. 2000).

- Ellis & Smith (2000) reported that Australian Open netball players (n=12) scored an average of 5.6 stages (range of 4-7).

Training to Improve Strength

Most throwing and striking sports require a transfer of force from the ground to achieve maximum acceleration of the upper limb as in netball. Therefore by training and strengthening the trunk, the body is able to transfer this force within the game.

Therefore, maintaining strength in training is vital, but too often power training to complement strength, is neglected. These two variables go hand, in hand and the one cannot be trained without the other. Strength is vital for power development and vice versa, especially at higher levels of force application (Kraemer & Gómez, 2001). Ellis & Smith (2000) stated that resistance and plyometric training effectively develop strength. Therefore, resistance and plyometrics training should be an important component in a netball player's physical preparation.

Flexibility

Kraemer & Gómez (2001) defined flexibility as "the ability to move joints in a needed range of motion depending on the demands of the sport itself" (p. 8). Flexibility is not a general attribute, but is specific to a particular joint or set of joints.

Flexibility varies greatly among athletes, with women typically more flexible than men because of genetic factors. It is not necessary for an athlete to have a maximal range of motion in every joint. It is only necessary that the athlete be able to perform the skills of their specific sport with effective range of motion. Flexibility is important for athletic performance in several ways. According to Kraemer & Gómez (2001), greater flexibility can improve performance after injury, increase the mobility of the joint, increase the elasticity of muscle tissue and increase athletic performance overall. Although recent studies have expressed concern that stretching before exercise actually reduces force and

power, flexibility training is still regarded as an important part of training (Schilling, 2000).

Unlike the other variables identified for measurement in this study, flexibility does not belong to the causative factors of movement, but to the morpho-functional properties. This means that flexibility helps govern motion. According to Apostolopoulos (2001), flexibility helps determine the efficiency of the athlete's other physical abilities and enhances the development of coordination and technique. In general, flexibility enhances performances in sport, because athletes can more easily reach effective ranges of motion.

Assessment of Flexibility

The assessment of flexibility requires combined joint action movements which enable netball players, such as goal shooters or defenders, to field or intercept low bounce passes (Ellis & Smith, 2000). Harvey and Mansfield (2000) emphasised that flexibility is joint-specific, and selection of test type must take this into account. For the purpose of this study, it was decided to select specific tests for the measurement of flexibility of the hamstring muscle group, quadriceps and calves, because all of these muscles are primarily involved in movement and most sporting actions.

Training to Improve Flexibility

Coaches sometimes think of flexibility training as stretching and often use stretching as part of warm-up routines. One purpose of stretching has been identified as the prevention of injury (Schilling, 2000). However, Calder (2000) declared that this is a myth, since there is no conclusive evidence in the literature of a relationship between stretching (warm-up) and the incidence of injuries. Hawley and Burke (1998) and Gambetta (1997) expressed similar views. In 1998, two large randomised trials involving army recruits showed no significant effect of pre-exercise stretching on the incidence of injuries, and in 1999 in a similar study using American recruits, it was shown that static stretching before training does not prevent injuries (Calder, 2000). Stretching exercises

give more freedom of movement, and can therefore be used to improve flexibility. Stretching will not, however, improve muscular endurance or strength (Kraemer & Gómez, 2001).

Flexibility is such an important part of exercise that coaches need to consider it as a workout itself, not a token warm-up or warm-down. Proper balanced flexibility training produces a balanced muscular system, and helps restore muscle function.

Speed

Penfold & Jenkins (1996:24) defined speed as "the ability to move the body or body parts through the required range of motion in the fastest time". Kraemer & Gómez (2001:7) called speed "the defining difference in many sports", as speed can be a vital attribute of strategy.

Kraemer & Gómez (2001:100) stated that "quickness allows small athletes to prosper in a big man's game". The importance of speed in netball is that speed can give the athlete the advantage over the opponent by being in a better position or getting into a position more quickly. Acceleration is critical for actions such as getting into position, evading an opponent or intercepting a pass, all of which are important requirements of the game (Ellis & Smith, 2000). Speed in netball allows the faster player to get quickly into the ideal position, to receive the ball, and to take it to the pole for a goal, while the slower player will not be able to get into a good position in the same time period. Alternatively, a fast player, as a defender, can put pressure on the attacker. Speed in forward, backward and lateral movements is important in many sports (Wells, 1991). With continuous stop-and-start movements (acceleration) in netball, speed approximates the concept of agility.

Assessment of Speed

Regarding the assessment of the speed, Ellis & Smith (2000) emphasised that netball requires high intensity repeated running efforts, averaging less than two seconds in duration. Therefore, the ability of a netball player to accelerate is indicated best by the sprinting times of 5 m, 10 m and 20 m (the maximum distance a netball player would run). With the assessment of speed, it is important that the test should be conducted on the competition surface, with competition shoes. Players must also have the opportunity to warm-up. A speed specific warm-up containing a few sprints and agility activities are recommended, because a poor warm-up may result in poorer results.

Unpublished results of the South African national netball team show that in 2001 their average speed over 10 m was 2.33 seconds. In 2002 it was 1.29 sec over 5 m and 2.1 sec over 10 m (South African Sports Commission, 2002).

Ellis & Smith (2000) reported the following results for Australian netball players:

- 1.15 sec (5m), 1.94 sec (10m) and 3.36 sec (20m) for South Australian Sports Institute players (1995).
- 1.15 sec (5m), 1.96 sec (10m) and 3.37 sec (20m) for Australian Institute of Sport U/21 players (1997).

Training to Improve Speed

Speed training must help the netball player to improve speed, meet her maximum speed potential required for netball and to apply the speed to the sporting environment (Penfold & Jenkins, 1996). To be able to perform speed training, the coach has to identify the specific sport's requirements and, according to Penfold & Jenkins (1996), analysis of each activity is essential. They stated that speed can be improved through training in the following areas:

1. Reaction to a signal, which can be improved by reaction drills.

2. Acceleration, the ability to reach maximum speed in the shortest possible time. Acceleration can be improved through acceleration drills and jump training, such as plyometrics.

3. Balance, the ability to execute one technique following the execution of another. Balance can be trained using lateral movement drills and proprioceptive drills (i.e., jumping/balance/stability drills).

4. Maximum speed. Speed can be trained using short repetitive sprinting drills.

5. Maintenance of maximum speed, which can be improved using innovative drills (i.e., running at full speed then on instruction, put in 4 fast rhythm steps) and absolute speed runs (i.e., 30 m-sprints).

6. Speed endurance, trained with repeated sprints and short recovery rest periods (i.e., 3 repetitions at 80% of full speed over 30 m, and 25 seconds rest between sprints).

Agility

Kraemer & Gómez (2001:7) defined agility as "the ability to stop and change direction quickly". They stated that agility is a total-body change, specific to the sport skill. There are not many sports that require the athlete to sprint only in a straight line. Additionally, some sports also require the ability to move with an object, such as a ball in netball.

The importance of agility in netball was identified by Ellis & Smith (2000) as its contribution to the basic movements, including different sidewards movements, sudden changes in direction, and quick stops and starts. They stated that a netball player can shuffle and do sideway movements between 100 and 300 times in a game at maximum speed, depending on the playing position. Therefore, agility in netball is very important.

Assessment of Agility

The 505-Agility test has been selected to measure agility in this study. This test requires the athlete to sprint 10 m as a run-up before sprinting 5 m, then to change direction on a specific foot, as instructed, and sprint 5 m back in the opposite direction. According to Ellis & Smith (2000), the 505 Agility test is a reliable and valid netball-specific test.

They reported the following results:

- 2.44 sec (left) and 2.40 sec (right) in Australian Institute of Sport U/21 netball players (1997).

Unpublished data from the South African national netball team in 2002 reported a mean result of 2.51 sec (left) and 2.47 sec (right) (South African Sports Commission, 2002).

Training to Improve Agility

Agility can be improved by training with ladders, or agility-specific running exercises. These are all regular training exercises in netball.

Muscle Endurance

Kraemer & Gómez (2001:9) defined muscular endurance as "the ability to perform repeated muscular actions", ranging from whole-body movements (i.e., a sit-up) to a single-joint movement, such as repeated wrist flexion. Ferreira (2001:44) referred to muscular endurance as "the ability to repeatedly perform sub-maximal muscular contractions". She stated that activities to promote muscular endurance must target specific parts of the body.

A netball player needs a certain amount of fitness in relation with muscular endurance to perform at near-maximum effort throughout a game. Therefore, training for muscular endurance is an important aspect of training programs for most sports (Kraemer & Gómez, 2001). Muscular endurance is also closely related to muscle strength.

Assessment of Muscle Endurance

Muscular endurance can be measured through any repetitive activity within a given time period, by measuring the maximum repetitions possible. For the purpose of this study, the assessment of muscular endurance was based on the one-minute passing test. This test is netball specific and measures the muscle endurance and strength of the player to perform as many chest passes as possible in 60 seconds. It is a simple field test that is not costly to conduct.

To my knowledge, this test has never been used for research purposes on netball players and therefore the validity of the test is not known. There are also no sport-specific normative data available. However in the last few years, many programmes have emphasised strengthening of the core, i.e., muscles of the trunk and pelvis, in addition to the muscles of the shoulders, arms and legs.

Training to Improve Muscle Endurance

Muscular endurance can be improved by either increasing whole body aerobic capacity, or by increasing the number of repetitions of the same exercise in a given time period. Most sports, including netball, involve throwing and striking actions. This requires a transfer of force from the ground to achieve maximum acceleration of the upper limb. Therefore by training and strengthening the trunk, the body is able to transfer this force within the game.

Sport-Specific Physical Profiles

According to Reaburn & Coutts (2000:22) "most team sports such as football, hockey, netball and basketball require the development of different physical capacities for optimal performances". The physical requirements for team sports include the following:

- To continually produce maximal or near-maximal sprints over the game time period of 60-90 minutes, thus requiring high levels of **aerobic fitness** (Bishop, 2001).

- To **recover** properly between bouts of activities (Tomlin & Wenger, 2001). This ability to recover from the last working bout is crucial. Proper recovery prevents an athlete from reaching a state of critical fatigue or even exhaustion (Bompa, 1994).

- To develop the physical capacity of **speed** in order to beat opponents, **endurance** that allows the athlete to recover and repeat sprint efforts, and **strength** that is needed for physical contacts (Coutts, 2001).

Ellis et al. (2000) identified the usefulness of field-based performance testing in helping coaches to determine the strengths and weaknesses of players in relation to the various components of fitness. The results of all the tests combine into a "physical performance profile" for each player. Team results can also be put together to form a physical performance profile for the team (Davis, 1996). One benefit of examining physical profiles is that it helps the coach to decide which aspects to concentrate on in practice sessions (Ellis et al. 2000). Comparing profiles from different times during the training years, will point towards changes in physical variables that have occurred, and where additional training may be needed. In other words, examining performance profiles provides important information for customised training (Davis, 1996).

Training for team sports takes on different dimensions when different physiological requirements are placed on players. Hawley and Burke (1998) described a

team sport such as hockey where the rules have changed (i.e. advent of synthetic playing surfaces), as one example. The rule change allows players to take a sideline whenever they are ready, without waiting for the referee's permission. This type of rule change, forces the players to be aerobically more fit, because there are shorter recovery periods during play. Rule changes like this, that decrease the interruptions during a game, increases the playing speed of a game and, thus, changes the physical demands on players.

Customised training implies that the strengths and weaknesses found during physical testing will guide the training load created in each practice session. According to Coutts (2001) determining the correct **training loads** for a team sport is a difficult task, because the coach has to include tactics, skills, endurance, strength, speed, agility, flexibility, etc., within the plan. Training all these variables can take a great deal of time and energy, so efficient approaches to training become important. For instance, Reaburn & Coutts (2000) found that a combination of sprint and endurance, training may lead to gains in both variables. Over an eight-week training period their study produced significant improvements in speed and endurance when players participated in concurrent training (sprint and endurance training activities combined).

Another factor in customised training is that many team sports have long seasons of several months in duration. According to Hawley & Burke (1998) the first thing to do when planning a training programme for a team is to divide the year into a playing season and an off-season. Coaching is further complicated during the in-season when the competitive demands are combined with bad weather, injuries and plateaus in fitness.

Pyne (1997) supported the concept of **periodising a training year** for team sports to address these problems. By the time the "in-season" phase begins, the players should possess a well-developed aerobic base that supports speed training, and a weekly competition program. At this stage more recovery periods need to be planned to replace speed training. In his opinion, the pre-season phase should be focussed on endurance, and the in-season phase should emphasise quality training and recovery.

The fundamental goal for any coach is to optimise the athletic performance of each individual in a team (Coutts, 2001). According to Clifford & Feezell (2000), many of the decisions in a team sport have to be made on behalf of the team by the coach. The training of physical variables required for performance, fall into this category. The coach will try to customise training in response to the profiles of physical performance defined during physical testing at the beginning of the training year, in order to optimise the progress made by players during the training sessions that follow.

Customised Training

Baker (1996) stated that customised training involves specific exercises to improve a certain skill for performance. For the purpose of this study customised training was defined as the specific training of an athlete or group of athletes on the basis of their physical fitness strengths and weaknesses. According to Norma Plummer, an Australian Netball Coach and Team Coach of the Year in 1997, one key to team success is the maintenance of a level of professionalism, and keeping ahead of other teams in training techniques (Wald, 1998). The implementation of customised training may provide teams with a competitive edge.

The contents of a customised training programme are based on optimal periodisation of the training year. The basic principles of training namely overload, recovery and specificity are important components of customised training. This is accomplished through manipulation of three key variables in programme planning, namely, training frequency, intensity and duration. The final programme is generally based on the results of pre-tests specific to the sport. Many coaches fail to realise the relationship between all these factors, and how these factors interact with each other (Fleck & Kraemer, 1982).

Rhea et al. (2002; 2003) explained the concept of periodisation in general terms as the manipulation of repetitions of exercises, number of sets, types of contractions, and frequency of training. Periodisation generally includes all aspects regarding the preparation of athletes for seasonal competitive programmes.

Rhea et al. (2002:250) explained that periodisation is “a system that will adapt to any changes athletes may experience in an attempt to meet the demands of stressors”. Periodisation was defined by Stone et al. (1999b:56) as “a logical phasic method of manipulating training variables in order to increase the potential for achieving specific performance goals”.

According to Stone et al. (1999b), one should identify different periods of preparation in a seasonal program. These periods will depend on the characteristics of the different sports, the length of the competitive season and the individual characteristics of the athletes. The selection of exercises with regards to frequency, intensity, and duration plays a vital role in successful periodisation. The primary goals of periodisation include the prevention of overtraining, peaking at appropriate times in the season, and providing maintenance programmes for the particular sport (Stone et al. 1999a).

The periodised training year is usually divided into 3 levels (Stone et al. 1999b):

1. Macrocycle (long length) – yearly. Planning the whole year with a certain amount of peaks for main competitions/games.

2. Mesocycle (middle length) – 4 to 6 weeks. This is the sport-specific build-up towards a season.

3. Microcycle (short length) – weekly. Weekly sessions, normally not more than two high intensity sessions after each other, with one day easy or rest in between.

Each macro- and mesocycle contains four phases: the preparation phase, the competition phase, the peaking phase and the transition or active rest phase (Bompa, 1994; Stone et al. 1999b). Each of these phases begin with high volume and low intensity training and ends with low volume and high intensity training. Each level and phase has different goals and requirements, which are dictated by the specific sport and the performance profiles of the individual athletes. Bompa (1994) made these comments:

- During the *preparation phase* and, in fact, throughout the entire year, aerobic training is important because it forms the general physiological base for physical, technical, tactical, and psychological preparation for the competitive season.

- During the *competitive phase* all training factors (i.e., speed, endurance, agility etc.) are trained to perfection to ensure that the athlete competes to the best of his/her ability.

- Following a long period of preparation and competition, the *transition phase* is the active rest period. To stay active, but rest the specific muscles used for the sport/activity, the athlete has to do a different activity. For example, a cyclist will swim for exercise. This is the linkage between two annual plans of training, which means that both the frequency and intensity of training have to be reduced progressively.

Principles of Periodisation

Damm (1996) stated that coaches often focus only on one of the basic training variables (i.e., frequency, duration or intensity), without considering the interrelationship among these variables.

The following four key principles guide decisions about how to manipulate frequency, intensity and duration of training in order to gain the benefits of periodisation:

Specificity

Hawley & Burke (1998) emphasised that there is no use in training vigorously for one sport, if you want to actually compete in another. Specific training is especially important in sports such as netball, where skilful, coordinated movements are essential (Hawley and Burke, 1998). Therefore, the closer the training activities are to what is needed in competition, the greater is the impact of training on game performance. Jones and Carter (2000) used the principle of specificity to decide which type of training (endurance, strength or speed) should be the focus for each practice session. Based on the specific aerobic and/or anaerobic requirements of a sport, a coach should decide on what training activities will best simulate the requirements of the game (Koziris, 1996).

In order to optimise training, the coach and players need to identify exactly which skills they use in the sport, and in game situations (Damm, 1996). For example, netball is

characterised by short bursts of high intensity physical bouts of exercise (Lau et al. 2001). Therefore, netball players have to train using short duration high intensity exercises. Any team must be able to understand the skills needed, and the movements that are performed in the sport, and then implement specific exercises that focus on these aspects (Manners, 2004). For example, in netball, training should focus more on anaerobic fitness than on aerobic fitness, i.e., through practice activities that focus on running into open spaces without the ball, and running to catch or intercept the ball.

Overload

Overload in training is defined by Van Borselen et al. (1992:74) as the "process of stressing the individual to provide a stimulus for adaptation by either increasing the volume and intensity of training". Rhea et al. (2003:82) described the principle of overload as the "process by which the neuromuscular system experiences loads to which it is not accustomed".

Overload is determined by the frequency of training (how often), intensity of training (how hard), and the duration of training (how long) (Hawley & Burke, 1998). Baker et al. (1994) perceived training volume as an important variable within the overload principle, because greater volume results in greater overload of the musculature. Overload can be achieved in two manners: firstly by gradually increasing the volume (number of repetitions) on a weekly basis. Secondly, by increasing the intensity of work done in a training session (or decreasing the amount of time for rest each interval). In netball, for example, overload could be increased by dividing the group into smaller groups to allow shorter rest periods between drills. The degree of adaptation depends on the degree of overload.

The training load that athletes can handle is not constant, and the rate of adaptation to specific training loads also varies between athletes. Damm (1997) stated that what may be an excellent training load for one athlete, may cause overtraining in another. This implies that training loads should ideally be individualised, however, in a team setting this may not always be feasible. Therefore, individual differences must be taken into account when setting goals.

The correct amount of overload is individualised, i.e., every athlete will react differently to the same training. This is part of the uniqueness of the human body. Therefore, Damm (1997) explained that this individual variation between players makes it difficult for coaches to progressively increase the training load of a team. Coaches have to recognise that individual players will adapt at different rates and to varying degrees to a training programme. According to Woolford & Angove (1991), the majority of coaches treat players within a team in the same manner with regards to training load, disregarding the different demands of each playing position and individual variation. Damm (1997) stressed that it is not enough for a coach to ask the players to give there best effort each time. The volume and intensity of each training session, as well as the progression in overload, must be carefully planned.

Tapering

Hawley and Burke (1998) described tapering as the reduction of training before competitions. They named four variables that can be manipulated during tapering, namely, duration, frequency and intensity. According to Reaburn (1998) the tapering period should last between 7 and 21 days, during which time the intensity and frequency should be reduced gradually over time. This tapering technique is presumed to lead to an improvement in subsequent performance.

In running and cycling, a reduction in the volume of training (up to 60% of normal distances) appears to lead to the best performance improvements. Despite reduced training loads, proper recovery periods are still important, and should be continued throughout the tapering period (Reaburn, 1998).

Recovery

Javorek (1987:43) defined recovery as the ability to “quickly regain 100 percent of physical, intellectual and psychological capacity, so that the athlete can begin a new workout or other activities with complete power, ability and skilfulness”.

Many sports require athletes to have high levels of muscular strength and aerobic fitness to be competitive in their sport (Sporer & Wenger, 2003). Athletes prepare and compete under time restrictions and sport demands (fitness level), and athletes need to train several fitness components during the same training phase. For example, an average preparation phase is 4-6 weeks long, but if the athlete needs to compete within 8 weeks after the transition phase, they cannot spend a third of their possible training time in the preparation phase. This may easily lead to overtraining. Therefore, proper recovery often determines whether an athlete will be successful or not. Rest and recovery is often neglected in training programmes, thus increasing the probability of overtraining (Hawley & Burke, 1998).

In order to avoid overtraining and fatigue, and thus induce full recovery, the coach has to plan a balanced, periodised training programme (Javorek, 1987). Recovery strategies must be routinely employed after training, and athletes must learn the importance of this part of the training programme. There are many recovery strategies that can be used, i.e., hot-cold-hot treatment (i.e., shower), relaxation (i.e., massage), or active rest (i.e., casual swimming).

Graham et al. (2003:338) stated that the "length and method of recovery should have direct influences on the performance of the players." i.e., the readiness of players before starting with a new exercise. Luebbers et al. (2003:709) confirmed this by stating that "it is important to determine appropriate training duration and post training recovery that will facilitate peak performance". In netball, where aerobic fitness is one of the important fitness components, proper recovery after aerobic training is critical towards the actual performance of the players (Hoffman et al. 1999).

Lau et al. (2001) found that athletes who play sports involving short bursts of high intensity exercise followed by brief recovery periods (such as netball), appear to recover just as well from passive recovery (reading a book), as they do with active recovery (swimming). Some athletes, however, may feel psychologically more recovered following active recovery, and this psychological effect may ultimately influence their performance.

Variables in Periodisation of Training

The three primary variables that can be manipulated to create the periodised of training effect are training frequency, intensity and duration.

Training Frequency

Training volume has been defined as "the total amount of work performed per session, per day, per month, and so on" (Stone et al. 1999:59). Bompa (1994:75) also defined volume as the "total quantity of activity performed in training". Hawley & Burke (1998:22) stated "that the volume of training is one of the key variables known to determine the degree of adaptation to training". Bompa (1994:75) confirmed that volume is one of the prime components of training and stated that volume is needed for "technical, tactical, and, especially physical achievements". According to Arheim & Prentice (2000) volume includes the duration of training, distance covered in training, and the number of repetitions of an exercise. To achieve improvement, the average person should train at least three sessions per week, but should aim for five sessions per week. Competitive athletes, on the other hand, may train as much as six sessions a week, and at least one rest day per week is incorporated for psychological and physiological recovery.

An athlete's performance can improve as a result of increasing the number of training sessions and the amount of work during each session. As the athlete improves, and is more capable of high level performances, training volume becomes increasingly important. According to Baker et al. (1994:235) volume plays an important role within the overload principle since "greater volume results in greater overload of the muscular system". Therefore, the greater the volume, the more the muscles are challenged to achieve higher workloads.

Training Intensity

The second variable to manipulate when planning training sessions is training intensity. Stone et al. (1999:59) defined training intensity as "power output". Power is calculated as work divided by time (work/time) and is related to energy consumption. Hawley & Burke (1998) explained that the greater the intensity of training, the more prolonged is the fatigue period and the longer the recovery time the athlete needs before he/she can perform the same load again. Athletes cannot train intensely every workout, nor should they try to. Sufficient recovery time should be allowed between sessions, and the different components of training should be carefully coordinated.

Arheim & Prentice (2000) are of the opinion that intensity is the most critical factor of training, particularly in the early stages of training, when the body makes a lot of forced changes in order to achieve certain workload demands. The American College of Sports Medicine (1995) recommends that in order to improve training status the intensity of exercise must be prescribed at 60 to 90% of maximum heart rate (HR_{max}) or 50 to 85% of VO_{2max} for the average athlete (Ellis & Smith, 2000).

Kutzer (1995) stated that although intensity is a key training variable, it is almost impossible to control in large groups of athletes. Intensity levels vary on a day-to-day basis due to many uncontrollable factors such as weather, the individual's health, and sleeping patterns. Furthermore, the intensity of exercise sessions varies according to the specific demands of a particular sport. The more work performed per unit of time, the higher is the intensity (Bompa, 1994).

According to Woolford & Angove (1991), the intensity of a training session is also a function of:

- Objectives of the session. Is the session only for skill development or to improve fitness levels?
- Phase of the training. In the beginning of the season, the coach will spend a lot of time explaining the activities, but as the players progress less time will be spent on this.

- Effort and commitment of players. Do the players always give a maximal effort?
- Sport specific drills. Are all the drills on the netball court for specific training or do the players perform activities on other surfaces?
- Number of players in a drill. How many players are actually active in the drill at a time?
- Amount of available equipment. How many balls are available to perform the drills?

Benecke et al. (2001) stated that the measurement of blood lactate concentration is the only objective measure of relative exercise intensity. However, Hawley & Burke (1998) contended that training intensity can also be monitored through the measurement of oxygen uptake and heart rate.

In this study, training intensity and volume was the only factors that could be manipulated due to the fact that a structured 45 min time period was set aside before each training session to complete the fitness training. Furthermore, training intensity was measured through heart rate monitoring.

Heart Rate Monitoring

Heart rate monitoring during exercise has become increasingly popular over the last few years for several reasons, but in particular for the instant feedback to the athlete. Cibich (1991:4) stated that “exercise heart rate is the simplest and most useful field measurement to quantify the intensity of training”. It is also known that heart rate is directly related to the intensity of exercise and to oxygen consumption (Cibich, 1991). Regular feedback regarding heart rates via the Polar team system was incorporated in this study. Although this system does not allow direct feedback, the feedback was provided and explained during the next exercise session.

In order to accurately prescribe training intensities based on heart rate, one must first determine an athlete's true maximal heart rate. It is important to note that if an athlete exceeds her laboratory determined maximal heart rate on the field or during training, that the highest heart rate achieved should be taken as the athlete's true maximal value (Hawley & Burke, 1998). They also stated that competition may cause excitement, which may cause a heart rate drift. Therefore, when monitoring the heart rate of an athlete, any unusual circumstances should be noted in the data analysis. Through the monitoring of heart rate, the athlete knows if the intensity is too high or too low, if he/she aims to exercise within a target heart rate range. Different heart rate training zones are identified in order to train specific components of fitness, i.e., aerobic or anaerobic capacities.

The most accurate method to determine maximal heart rate involves exercising an individual with progressive increments in intensity to exhaustion, while monitoring the heart rate (Hawley & Burke, 1998). This is best done in controlled laboratory conditions. Alternatively, age-predicted maximal heart rate can be estimated using a mathematical formula, such as 220-age (Plowman & Smith, 1997). However, this is not as accurate as the direct measurement of maximal heart rate.

Monitoring the heart rates of team sport players allows sport scientists to obtain estimations of the relative energy demands of the specific sport and playing positions (Hawley & Burke, 1998). They state that team sports require athletes to do short bursts of sprinting with rest periods in between, and the distances covered are between 5 m and 25 m. Therefore it is not surprising to find that players exercise close to their maximal heart rates for sustained periods of time throughout a game, while spending at least half of the game in a range greater than 85% of maximal HR.

Woolford and Angove (1991) showed that in national level netball players during a tournament for National titles, the average heart rate was more than 50% of the total time in zone 2 (between 85% and 95% of maximum heart rate). The player's

heart rates ranged between 56% to 74% of the total playing time and were above 85% of their maximal heart rates.

Arheim & Prentice (2000) recommended that with continued training (for the whole session), it is more desirable to train at 60-80% of maximal heart rate to improve aerobic fitness. According to Reaburn (1998), training at 80% of maximal heart rate during the **tapering** phase will either maintain or sometimes reduce performance. Therefore, within this training phase it is important to maintain the intensity level, and keep the heart rate at maximal levels, with rest periods in between for recovery.

Training Duration

For improvement of fitness, an individual must participate in at least 20 minutes of continuous activity with a heart rate in excess of 70% of maximum (Arheim & Prentice, 2000). They stated that the average athlete should train at least forty-five minutes at a heart rate between 60-90% of maximal heart rate to improve fitness. The ACSM recommends 20 to 60 minutes of continuous aerobic activity, although improvements in cardiorespiratory endurance have been demonstrated with 5 to 10 minutes of very high intensity exercise 4 times per week for an average athlete (American College of Sports Medicine, 1995). Very high intensity exercise is described as exercise greater than 90% of maximal heart rate.

Bompa (1994:89) referred to duration (or density as he called it) as the "relation between working and recovery phases of training expressed in time". The efficiency of a training programme is dependent on the prevention of fatigue and overtraining of the athlete. Thus, the duration of each training session must be varied according to the volume and intensity of the training load. Many sports represent a pattern of short-duration, high-intensity exercise such as netball. Of the three principles of training, the manipulation of exercise duration is probably slightly less important than adaptations in the frequency and intensity of training.

Special Considerations in Customised Training

Overtraining

Overtraining was defined by Stone et al. (1991:35) as periods when the "athlete's performance plateaus or decreases due to the training program". According to Fry et al. (1994) overtraining involves either a short- or a long-term imbalance between recovery and training, and it results in fatigue and performance decrements. Jeukendrup & Hesselink (1994) proposed that overtraining is frequently observed in sport training. Hawley and Burke (1998:335) stated that "all the top international athletes wake up in the morning feeling tired and go to bed feeling very tired". Athletes can experience tiredness for many reasons, such as poor nutrition, a shortage of sleep, a shortage of recovery, and/or overtraining. The increase in training volume or intensity during the preparation and competitive phases of a programme, can also lead to overtraining.

In a volleyball training study by Piper (1997), one of the major concerns was the prevention of overtraining. According to this study, coaches need to closely monitor athletes for symptoms, such as mental fatigue or illness. Within team sports it is even more difficult to pick up these symptoms, especially when the management staff has to monitor from 10 to 20 players at once. In Piper's study (1997), the intensity was decreased to a comfortable level for the athlete to prevent overtraining. The decrease in intensity worked well, since no athlete suffered from any kind of overtraining injury during the study.

It is possible to prevent or overcome overtraining by including rest and recovery periods as a planned part of the training programme (Bompa, 1999). Coaches need to recognise the importance of rest periods in training to reach excellence in performance.

Warm-Up Strategies

Because periodised training works on the principle of creating overload, warm-up activities are critical for every practice session. Bompa (1994:132) defined warm-up as the "physiological and psychological preparation for the training task to come".

The outcome of any warm-up should be an increase in the body temperature, improved motor performance, cardiovascular and respiratory changes, and increased motivation. In general, it is also presumed that a good warm-up may prevent injuries, although it has not been shown scientifically yet. According to Bompa (1999), a warm-up should help the athlete to reach a state of high efficiency (readiness) before training or competing, regardless of other possible physiological advantages.

Bompa (1999) suggested that a warm-up should consist of two parts, namely a general warm-up and a sport-specific warm-up. The general warm-up should last for approximately 20 – 30 minutes, and should include exercises of progressively increasing exercise intensity, as well as stretching. The specific warm-up of 5-10 minutes should include sport-specific activities, and should be performed just before the actual training session or the competition.

As an alternative to the static stretching warm-up routine, many Australian teams are using a dynamic warm-up. Rutledge & Faccioni (2001:20) explained dynamic warm-up "as a warm-up where static stretching has been minimised or completely removed from the warm-up process and replaced by stretching that is dynamic in nature". For example, swinging the arms when walking is a dynamic stretching exercise where both the lower and upper body are warmed up. According to Rutledge & Faccioni (2001) this principle can be applied to the whole body.

Feedback as Motivation

Feedback involves communication about the athlete's performance from the coach, video analysis, team mates, or anyone else observing the performance. Examples of feedback strategies include verbal communication (immediately before and after training sessions or competitions), video analysis, biomechanical analysis, and heart rate monitoring.

From a psychological point of view, Potgieter (1997) suggested that although the relationship between feedback and performance trends to improve is complex, it appears that sport performance tends to improve when combining goal setting with feedback. To

give effective feedback, the athlete's performance has to be measured correctly. In terms of intensity of training (the single variable that could be manipulated in this study) the heart rate monitor was chosen as the means of getting information on playing intensity. In this way, players could use the information about their heart rates to get a feeling of the intensity of their training sessions. This information could serve to motivate them to pay attention to the level of intensity of their training. For this study the Polar Team System was chosen as the measurement instrument to provide this motivational feedback.

Polar Team System

> Heart rate monitors are widely used by many sports people in order to optimise their training. The advantage of the Polar heart rate monitor is that the data is downloadable on a computer, and is therefore available for detailed analysis.

Polar has designed the Team System especially for team sports where the computer for the system is in the belt itself, which is placed around the chest. Therefore, no watch is necessary and the belt is manually set with the computer, prior to use.

One disadvantage of this system is that the athlete cannot get instant feedback about the data, since it has to be downloaded first via computer. An advantage of the system is that within the rules and regulations of most team sports, players are allowed to wear these transmitters, while the watch is not permitted in game situations.

Since the Polar Team System is relatively new, no previous studies could be found on the application of the results obtained with this system.

Conclusion

A team cannot truly be a team without the respect of team mates for each other and respect for the coach (Clifford & Feezell, 2000). Team sport players have to cooperate and communicate with their team mates, as they have to have the physical capabilities to move quickly into an open position to receive passes, drawing opponents away from play, or blocking opponents. The development of the physical variables of netball performance demand carefully planned training (Manners, 2004), which means that the coach or person responsible for planning the training year must understand the specific demands of the sport (Young, 1991). Information about the status of the players to be trained is the starting point for training plans. This is where the physical performance profile becomes important. By taking the results of players' performances on a battery of netball relevant tests, a picture of the physical status of the players is created. This picture reveals strengths and weaknesses that can guide the planning of a customised training program.

Chapter Three

Methodology

This study examined the effect of customised training on the physical fitness variables in a team sport, namely, netball. Included in this chapter is the design of the study, the procedures followed for the specific tests and a description of the data analysis. The purpose of the study was to determine if a customised training programme affected the physical fitness of first league netball players. This study was based on the Australian protocol of physiological tests for the assessment of netball players (Ellis & Smith, 2000). Understanding the game of netball and its specific requirements was the first step in designing the test protocol.

Research Design

An experimental design was followed. Pre-testing of an experimental and control group was followed by an intervention programme for the experimental group. Comparisons between pre-test and post-test scores were used to determine the impact of a 9-week intervention programme on the physical fitness of the experimental group. Results were also analysed to compare the changes in physical fitness between subjects of the experimental group and the control group during participation in one competitive season of netball.

Selection of Subjects

Several local netball clubs were contacted and invited to participate in this study. The 5th and 6th teams from Maties Netball Club (n = 14 players) were included in the experimental group. The coach for these two teams agreed that the researcher could administer the customised fitness training sessions over a 9-week period. The Helderberg Netball Club served as the control group. Their 1st and 2nd teams (n = 16 players) played in the same league against the Maties 5th and 6th teams, which made them a suitable control group for this study.

Testing was completed during practice times on a court at the different clubs. Pre-testing was completed in the beginning of April 2004, and post-testing was completed at the end of May 2004. Before any player could take part in the study, an individual consent form was signed (see Appendix A). Both the purpose of the study and procedures were explained to the players. The importance of attending all practices and their availability for post-testing were highlighted prior to asking for signatures.

Procedures

Test Selection

Physical fitness requirements relevant to netball were selected based on the review of the literature. For each physical variable identified, an appropriate statistical test was selected in order to determine if there were any changes after the customised training programme of 16 weeks was implemented.

Aerobic Fitness – Multi-Stage Fitness Test (Bleep Test)

The multistage fitness test was selected to determine the aerobic fitness of the players (Ellis & Smith, 2000). For this test, two lines, 20 m apart, were marked on a netball court. All the subjects ran together back and forth on a 20 m straight path, one or both feet must cross the 20 m line at the precise moment that a sound signal was emitted from an audio cassette.

The frequency of the sound signal increased in such a way that the running speed was increased by 0.5 km/hr each minute, from an initial running speed of 8.5 km/hr. As the subject ran, the audio cassette informed the tester at which level and shuttle the subject was. There are between 9 and 16 shuttles per level.

No warm up was necessary for this test. Subjects received two warnings for not reaching the line at the time of the auditory signal. With the third warning, the test was

terminated for that individual. The score was taken as the last shuttle where the subject's foot crossed the line prior to, or at the same time as the signal. Only one trial was allowed. All the subjects perform together in this test.

Equipment: 20 m non-slippery flat surface

Cassette player and audio cassette with test.

20 m Tape measure.

Marker cones.

Anaerobic Fitness - Repeated Sprint-Ability Test

The purpose of this test was to measure the subject's speed-endurance, muscle endurance of the legs and lower back, ability to resist intermittent high intensity fatigue, and agility (Johnson & Nelson, 1986).

For this test, five beacons were placed 5 m apart on a straight line. Subjects started at point 0, and upon an auditory signal (by the head time keeper), sprinted to cone 1, touching the base of the cone with the hand, returning to point 0, reaching down to touch the base, and then sprinting to point 2. The subject continued in this manner sprinting to the remaining beacons (3, 4 and 5) making sure to return to point 0 between each outward shuttle. A whistle was blown after 30 seconds, which indicated the end of that stage of the shuttle-run. At this time the subject was allowed to take a 35-second recovery period (rest period timed by another time keeper), and the subject's distance (to the nearest two and a half meters) covered during the 30 seconds exercise period was recorded. The distance measured was recorded from the position of the front foot of the subject as the whistle was blown. During the recovery period, the subject had to make her way back to the start point (0) and upon completion of the 35 seconds, began the next set of shuttles. Six 30-second periods were completed by each subject. For each run, the distance the subject covered, was recorded.

The aim of the test was to cover as much distance as possible in the six runs. To assist with pacing, the subjects were advised to complete each run at about 90% of their maximum pace.

Equipment: Six cones.

Tape measure.

Non-slippery surface of 30 meters.

2 stopwatches.

Whistle.

Power - Vertical Jump Test

The vertical jump test measures explosive leg power and jumping ability (Ellis & Smith, 2000). The starting position for this test requires the subject to stand with her right side (hip) against a wall, onto which a measuring tape was fastened. The subject reached up with the right hand to touch the board at the highest possible point (heels of the feet stayed on the ground). This point was recorded as her "standing reaching height". Then the subject was instructed to dip her fingertips (right hand) in chalk. The subject had to jump as high as possible, using a two-feet take-off (without taking any steps), but using knee flexion and arm swing as momentum. At the top of the jump, the subject had to mark the board with her fingertips. The subject was allowed three trials.

The score for the jump was the difference between the "stand and reach" height and the height achieved at the top of the jump (Ellis & Smith, 2000). The best of the three trials was recorded to the nearest centimeter. If the subject took any form of step or shuffle prior to the jump, the score was not counted.

Equipment: Wall-mounted vertical jump board (or measure tape).

Chalk.

Strength – Seven Stage Abdominal Test

The purpose of the seven stage abdominal test was to determine the strength of the abdominal muscles, i.e., the trunk (Ellis & Smith, 2000). Each of the seven stages is progressively more difficult as the positions of the hands and arms are modified. The aim of the test was for the subject to complete as many of the stages as possible.

The starting position for the subject was lying supine on the floor with a 90° bend at the knee (sit-up position), the feet (without shoes) comfortably apart and in contact with the floor. The feet were not held or stabilised by another person or piece of apparatus. All movements were conducted in a smooth, controlled manner.

The subject was instructed to keep the arms straight with hands resting on thighs, then move forward until the fingers were touching the patella (Stage 1). Stage 2 was achieved if the subject continued by keeping the arms straight with hands resting on thighs, moving forward until the elbows were touching the patella. Stage 3 was achieved with arms crossed and in contact with the abdomen, and with hands gripping opposite elbows. The subject had to move forward until the forearms touched the mid-thighs. Stage 4 was achieved with the arms crossed in front of the chest, while the hands gripped the opposite shoulders. The subject then had to move forward until the elbows touched the mid-thighs. Stage 5 was achieved with the arms bent behind the head and the hands gripped the opposite shoulders. The subject had to move forward until the chest touched the thighs. Stage 6 was attempted in the same position as Stage 5, but with the 2.5 kg weight in the hands and without gripping the shoulders. Stage 7 was also initiated from the same position, but with the 5 kg weight in the hands. The subject was allowed three attempts to pass each stage. The subject's score was the last completed stage.

An attempt was unsuccessful if the subject:

- Lifted either foot partially or totally off the floor.
- Threw the arms and or head forward in a jerky manner.
- Moved the arms from the nominated position.

- Lifted the hips off the floor.
- Failed to maintain a 90° angle at the knee, or was unable to complete the requisite sit-up.

Equipment: Weights (2.5 kg and 5 kg).

Flexibility - Straight Leg Raise Test

The straight leg raise test was used as explained in DISSA General Protocols (2002). This test measures a combination of active hamstring, gastrocnemius and soleus flexibility. To start the test, the subject is supine and face up with the arms at her sides, palms up and head on the floor. The subject was then instructed to raise one leg from the floor trying to take her leg past 90° as far as possible, while keeping the hips and back on the floor with knee extended and palms down. The opposite leg was fixed by another test administrator so that there was no flexion at the hip joint.

The test administrator identified the subject's anterior superior iliac spine (ASIS) and mid-point of the patella. The fulcrum of the goniometer was placed on the greater trochanter, while the moving arm was aligned with the midline of the femur using the lateral epicondyle as a reference point. The stationary arm of the goniometer was aligned with the lateral midline of the pelvis. The subject had only one trial. The horizontal angle of displacement was measured. The procedure was repeated for the other leg.

Equipment: Goniometer.

Table.

Flexibility - Modified Thomas Test

The purpose of this test was to assess the flexibility of the iliopsoas and quadriceps muscle groups (Johnson & Nelson, 1986). In the starting position for the Modified Thomas test, the subject sat on the edge of the plinth. The subject was instructed to roll back onto the bed and pull both knees to the chest. This was to ensure that the lumbar spine was flat on the bed and the pelvis posteriorly rotated. The subject was then instructed to hold the hip of the non-measuring leg in maximum flexion with the arms, while the limb to be tested was lowered towards the floor.

Two angles were measured using a goniometer for each leg:

- The flexibility of the iliopsoas was determined by measuring the angle of hip flexion. The stationary arm of the goniometer was aligned with the lateral midline of the pelvis. The moving arm was aligned with the midline of the femur using the lateral epicondyle as the reference point.

- The flexibility of the quadriceps was determined by measuring the knee flexion angle. The stationary arm of the goniometer was aligned with the lateral midline of the thigh, using the greater trochanter as the reference point. The fulcrum was placed over the lateral epicondyle of the femur. The moving arm was aligned with the lateral midline of the fibula, using the lateral malleolus as the reference point.

The greatest angles of displacement as measured by the goniometer were recorded (DISSA General Protocols, 2002).

Equipment: Examination bed.

Goniometer.

Flexibility - Ankle Mobility Test

The purpose of this test was to measure the range of motion of the subject's ankle joint in a functional position. The test indirectly measures the flexibility of the soleus and gastrocnemius muscles. This test is described in the DISSA General Protocols (2002). The testers started by finding the inferior tip of the lateral malleolus and the midline of the lateral aspect of the head of the fibula.

In the starting position for testing the soleus, the subject assumed the astride-straddle standing position, without shoes (heel of front foot about 5 cm in front of toes of back foot). The subject maintained a neutral position of the subtalar joint to prevent pronation. The subject was instructed to bend the back knee forward in line with the second toe until the heel was raised off the ground or until discomfort was experienced around the ankle. The angle was measured with the fixed arm of the goniometer perpendicular to the ground, and the other arm in line with the midline of the lateral aspect of the head of the fibula.

When testing the gastrocnemius, the subject assumed the same astride-straddle standing position, as described with the soleus above, however, this time the front leg was further away from the back leg. The back knee was extended throughout the test. The front knee was bent or the front foot was moved further away until the heel was raised off the ground. The angle was measured with the fixed arm of the goniometer perpendicular to the ground, and the other arm in line with the midline of the lateral aspect of the head of the fibula. The angle formed by the shaft of the tibia relative to the vertical axis for both tests, for both the left and the right ankles, were recorded. The subject had only one trial for each leg.

Equipment: Goniometer.

Speed – 5 m, 10 m, 20 m Sprint Test

The purpose of this test was to determine the subject's maximum sprint speed and the ability to accelerate from a stationary position (Ellis & Smith, 2000). The subject was asked to produce a maximal effort in these tests, and therefore was instructed to warm-up thoroughly before the test on their own as necessary. For this test, an electronic sprint timer with photo-electric sensors was set at chest height and placed at 5, 10, and 20 m intervals from the start line. The subject was instructed to position herself, in a standing start position, 30 cm from the start line. Each subject completed two runs at maximum effort, separated by a 5-10 minute recovery period. The instantaneous times at 5, 10, and 20 m for each run were recorded and the fastest split and total time attained during either run was determined (South African Sports Commission, 2002).

Equipment: Photo-electric sensors.

Tape measure.

Marking cones set at 0, 5, 10 and 20 m intervals from the starting line.

Agility - Netball Agility Test

The purpose of this test was to measure the subject's netball specific speed and agility (South African Sports Commission, 2002). For this test, the electronic sprint timer with photo-electric sensors was set at knee height, and placed at 0, 5 and 10 meter intervals. The subject was instructed to position herself in a standing-start position, close to the start line, without breaking the beam of the start sensor. Upon command the subject had to sprint maximally to the 10 m mark, cross the line with one foot, then turn left or right and sprint back through the 5m mark. The time taken to cross the 5 m mark on her return was the time recorded for the test.

The test involved a single change of direction on either the right or left foot. The electronic timing device recorded the times and the test was performed twice on both feet.

Equipment: Photo-electric sensors.

Tape measure.

Marking cones set at 0, 5 and 10 m intervals from the starting line.

Muscle Endurance – One-Minute Passing Test

The one-minute passing test measured the muscle endurance of the netball player's upper body. For this test, a line (one meter in length) was measured out 3 meters from the wall. The subject's starting position was with the front foot behind the 3 m line in a comfortable chest pass position with the ball in both her hands. The subject was instructed to start on the signal, completing as many chest passes against the wall as possible in one minute. If the ball was dropped and rolled away, the time continued. Therefore, the subject had to retrieve the ball and continue passing before the one-minute was over if any additional points were to be scored. The subject was allowed one trial only.

The score for the test was the number of passes completed in one minute. Only chest passes were counted and if the subject stepped over the line towards the wall, the pass was not counted.

Equipment: Wall.

Tape/Beacons (3 meter mark).

Netball ball.

Stopwatch.

Protocol for Data Collection

The following sequence of events guided data collection during both the pre- and post-test.

Testing Personnel

Six test administrators were recruited from the Department of Sport Science, Stellenbosch University. The volunteers were all students at the department with two to three years of experience in field testing. The volunteers were trained during one session to learn the correct procedures for test administration according to the protocol for this study. The same testers were used for all the testing of both groups.

Pre-Test

Every player signed the consent form and handed it to the investigator before any tests were conducted. Each test and procedure was explained and demonstrated to the players. All the tests were completed in two sessions (one session each day).

Intervention Programme

For the purpose of this study, customised training was defined as the specific training of a group of subjects on the basis of their physical fitness strengths and weaknesses, as identified in their physical profiles derived from the physical test results. The results of the pre-tests of the experimental group were compared with the normative data available. Based on this comparison, the investigator decided to focus on power, speed, agility, aerobic fitness, anaerobic fitness and strength during the intervention programme.

The intervention programme ran for the first two months of the season. During this 9 week period, 23 customised sessions were completed with the experimental group. Each training session was delivered during the first 40 minutes of each team's practice session. Data were also gathered by the Polar Team System during three scheduled games. The first two sessions were used for pre-testing. Sessions 3 to 21 were focused on training according to the customised training programme. The last two sessions were used for post-testing. The following general pattern was followed during each of the 45-minute training sessions:

- Warm-up.
- Optional passive stretching period.
- Dynamic exercises.
- Power training
- Strength training (focused on ball activities)
- Speed and agility training
- Each training session ended with a 2-3 minute stretching period, where each player had to stretch on her own time with specific instruction.

A detailed description of each of the 23 training sessions is provided in Appendix C.

Post-Test

The same tests and test sequence was followed during the post-tests as was followed during the pre-tests. The two post-test sessions for the experimental group were conducted during the two sessions that followed session 23 of training, and the control group followed the week thereafter.

Statistical Analysis

The paired t-test was used to compare the pre-test and post-test results of the experimental group. The unpaired t-test was used to compare the pre-test and post-test results of the control group and the experimental group with the control group. Results were considered statistically significant if $P<0.05$.

Summary

This study was aimed at determining the effectiveness of a customised team training programme on selected physical variables relevant to netball. Decisions made about customising training were based on the physical profiles established during the pre-tests of the experimental group. Pre-tests were also administered to a control group. Following the intervention programme, post-tests were administered to both the experimental and control groups.

Chapter Four

Results

This study was an attempt to examine the potential of a customised training programme to improve some of the physical variables needed to perform well in team sports, specifically netball. Data for this study were collected within 9 weeks on two groups of netball players who competed in the same league. Thirty netball players (N=30) participated in the study, of which fourteen (N=14) players were in the experimental group. They completed the customised training programme as an intervention (Appendix C), while the control group (N=16) followed their regular training programme.

From the pre-test results of the experimental group, the weakest physical variables were identified and a customised training programme was designed and implemented in an attempt to improve the players' status. The customised training programme was designed on the team's weak points not the individual weak points. The norms used to interpret test scores were developed from data of netball players tested at the Department of Sport Science, Stellenbosch University, between 2000 and 2003 and originally based on Ellis et al. (2000:302) work on netball players.

In the tables, the norms for each specific test were divided into 3 categories. The number of players in each category (expressed as a percentage of the total group), is also indicated in the table. The individual results for each specific test are presented in a bar graph. The solid line on the graph indicates the norm for an average result.

Pre-Test Results for the Experimental Group

Aerobic Fitness

Multi-Stage Fitness Test (Bleep Test)

This test measures the aerobic fitness of a player. The group average for this test was 8.51 shuttles ± 1.9 (Figure 1), which equates to an estimated VO_{2max} value of 42.56 ± 6.7 $ml.kg^{-1}.min^{-1}$. 64% of the players had VO_{2max} values lower than 46 $ml.kg^{-1}.min^{-1}$.

It was therefore concluded that the group had average aerobic fitness levels which was considered as a weak point.

Table 1. Norms for the Estimated VO_{2max} values.

	VO_{2max} ($ml.kg^{-1}.min^{-1}$)	**(%)**
Excellent	>55	0
Good	47 – 54	36
Average	40 - 46	21
Need some work	33 – 39	43
Needs a lot of work	<33	0

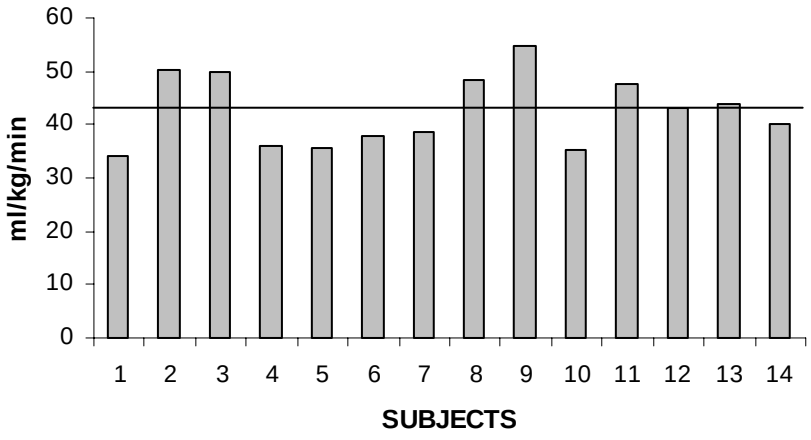


Figure 1. Pre-test results for the multi-stage fitness test.

Anaerobic Fitness

Repeated Sprint-Ability Test

This test measures the anaerobic fitness of the players. The group average for this test was 616.33 ± 45.7m which fell into the "need some work" category (Table 2). Less than 50% of the players scored above average in this test. The anaerobic fitness was considered a weak point.

Table 2. Norms for the Repeated Sprint-Ability Test.

	Distance (m)	(%)
Excellent	720 – 760	7
Good	690 – 719	21
Above average	670 – 689	14
Average	640 – 669	7
Need some work	600 – 639	51
Needs a lot of work	550 – 599	0

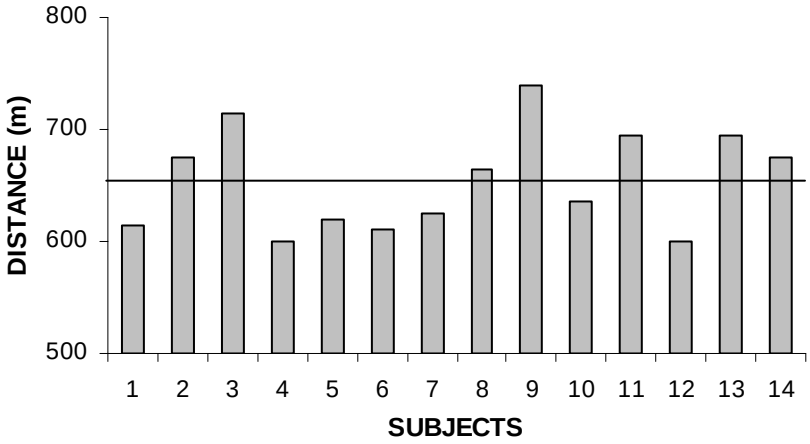


Figure 2. Pre-test results for the repeated sprint-ability test.

Power

Vertical Jump Test

This test measures leg power which is important for activities such as jumping, acceleration, speed and change of direction (Figure 3). The average score for the group was 40.36 ± 5.8cm (thus average). 57% of the players scored in the "need some work" category and 21% in the "average" category (Table 3). This fitness component was also considered a weak point.

Table 3. Norms for the Vertical Jump Test.

	Jump Height (cm)	(%)
Excellent	>55	0
Good	48 – 54	14
Average	41 – 47	21
Need some work	35 – 40	57
Needs a lot of work	<35	7

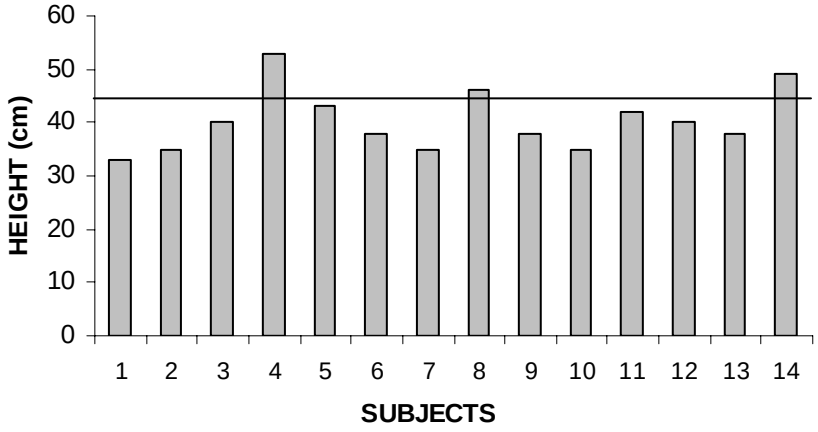


Figure 3. Pre-test results for the vertical jump test.

Strength

Seven Stage Abdominal Test

This test measures the strength and muscular endurance of the abdominal muscles without using the hip flexors (Figure 4). It gives an idea of how strong are the core stabilizers. The average score for the group was 3.71 ± 1.3 levels. 57% of the players were considered average and above (Table 4). Abdominal muscle strength and endurance was not considered a primary weak point for the team.

Table 4. Norms for the Seven Stage Abdominal Test.

	Levels	**(%)**
Excellent	>5 levels	29
Average	4 levels – 5 levels	28
Need some work	<4 levels	43

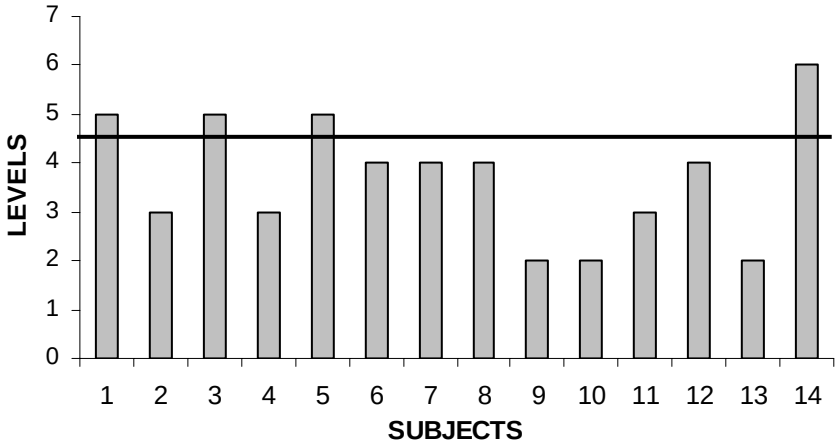


Figure 4. Pre-test results for the seven stage abdominal test.

Flexibility

Straight Leg Raise Test

This test measures the flexibility of the hamstring muscles. The average score of the experimental group was 70.92 ± 10.9º (left) and 71.57 ± 6.9º (right) (Figure 5). According to the norms (Table 5), all the players were categorized in the bottom class ("need some work"). It was therefore identified that the players lacked hamstring flexibility.

Table 5. Norms for the Straight Leg Raise Test.

		Left (%)	Right (%)
Excellent	>100º	0	0
Average	90º-99º	0	0
Need some work	<90º	100	100

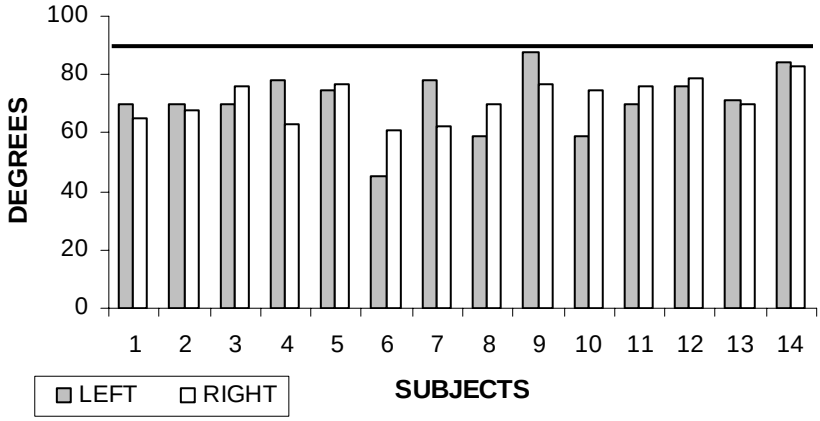


Figure 5. Pre-tests results on hamstring flexibility.

Modified Thomas Test

This test measures the flexibility of the quadriceps (front thigh) muscle group and the iliopsoas (hip flexors) muscles. A score greater than 180º is reported as a negative value to indicate that the actual value is greater than 180º. The average score on the pre-test for the experimental group was 67.21 ± 10.9º (left quadriceps), 68.93 ± 12.9º (right quadriceps), 178.86 ± 7.9º (left iliopsoas) and 179.07 ± 6.2º (right iliopsoas). According to the norms (Table 6), 79% of the players had scores greater than 60º for the quadriceps muscles in both the left and right legs. More than half of the players (64%) had a score of average or better for the left leg, while 43% of the players scored in these categories for the right leg. Therefore, flexibility of the quadriceps was not considered a weak point in this group (Figures 6 and 7).

Table 6. Norms for the Modified Thomas Test.

	Quadriceps	Left (%)	Right (%)	Iliopsoas	Left (%)	Right (%)
Excellent	>60º	79	79	>-5º	21	14
Average	50º – 60º	21	14	180º – (-4º)	43	29
Need some work	<50º	0	7	<180º	36	57

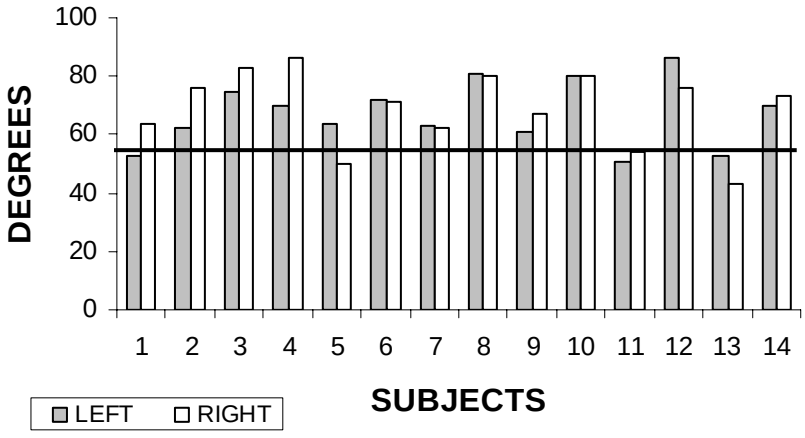


Figure 6. Pre-test results for the modified Thomas test (Quadriceps).

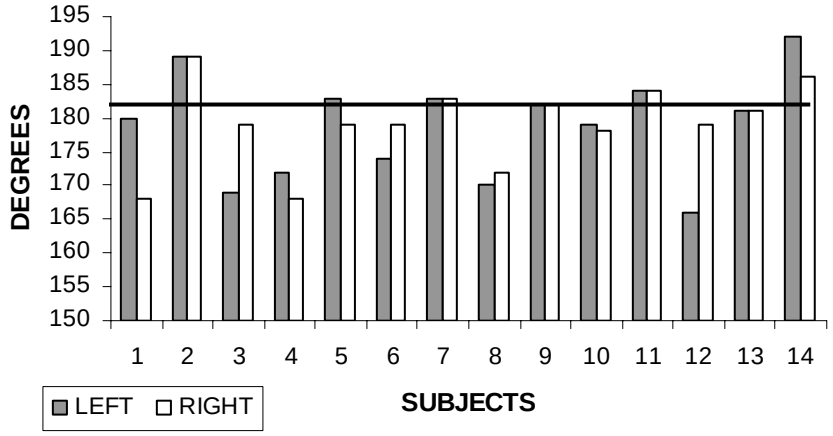


Figure 7. Pre-test results for the modified Thomas test (Iliopsoas).

Ankle Mobility Test

This test measures the flexibility of the soleus and the gastrocnemius muscles which are part of the calves. The score for the ankle mobility test should fall within a 10º range. The average scores for this test were 48.07 ± 5.6º (left soleus), 44.93 ± 4.4º (right soleus), 41.14 ± 4.6º (left gastrocnemius) and 43.21± 7.9º (right gastrocnemius) (Figures 8 and 9). According to the norms (Table 7), all the players were in the excellent category for these four tests.

Table 7. Norms for the Ankle Mobility Test.

	Soleus	**Left (%)**	**Right (%)**	**Gastrocnemius**	**Left (%)**	**Right (%)**
Excellent	>30º	100	100	>20º	100	100
Average	15º – 19º	0	0	15º –19º	0	0
Need some work	<25º	0	0	<15º	0	0

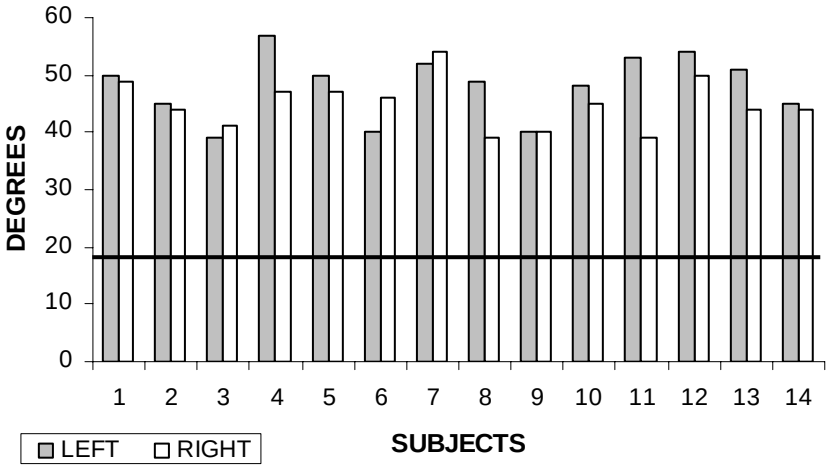


Figure 8. Pre-test results for the ankle mobility test (Soleus).

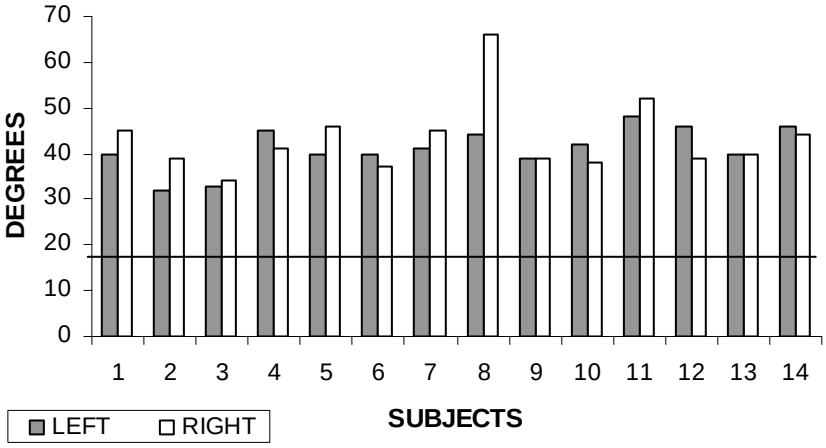


Figure 9. Pre-test results for the ankle mobility test (Gastrocnemius).

Speed

20 m Sprint Test

This test measures the body's ability to move at a high rate over a short distance of 20m (Figure 9). The group average for this test was 1.19 ± 0.1sec (5m), 2.02 ± 0.1sec (10m) and 3.47 ± 0.3sec (20m). In general, the players can be considered "average" in this activity as only two players scored in the "good" category over any distance (Table 8). The players' sprint ability was therefore considered a weak point.

Table 8. Norms for the 20 m Sprint.

	0-5m (sec)	(%)	0-10m (sec)	(%)	0-20m (sec)	(%)
Excellent	<1.00	0	<1.74	0	<3.25	7
Good	1.01 – 1.09	7	1.75 – 1.89	21	3.25 – 3.34	29
Average	1.19 – 1.10	57	1.9 – 2.04	29	3.35 – 3.49	14
Need some work	1.36 - 1.20	36	2.05 - 2.19	50	3.5 - 3.69	43
Needs a lot of work	>1.37	0	>2.20	0	>3.7	7

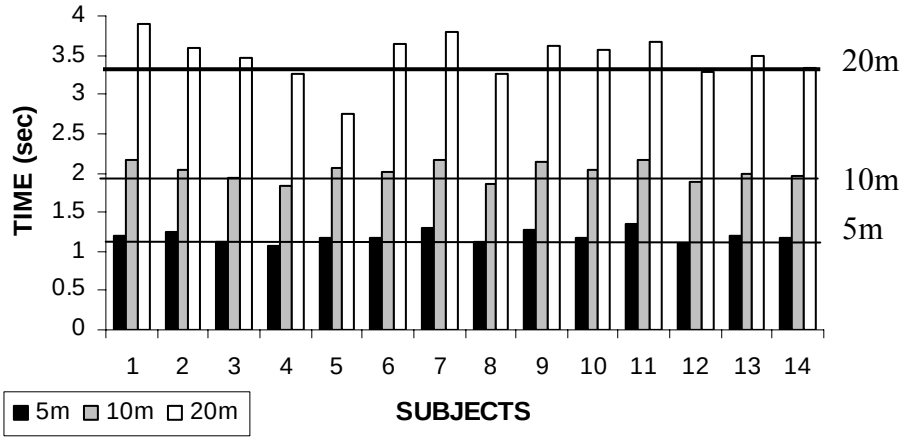


Figure 10. Pre-test results for the 20 m sprint test.

Agility

505-Agility Test

This test measures the ability of the players to change direction and sprint in different directions (Figure 11). The group average for this test was 2.66 ± 0.1sec (left) and 2.67 ± 0.1sec (right). According to these results 79% (left) and 72% (right) of the experimental group were in the "need some work" category (Table 9). Agility was thus considered a weak point.

Table 9. Norms for the 505-Agility Test.

	Time (sec)	Left (%)	Right (%)
Excellent	<2.35	0	0
Good	2.36 – 2.44	0	0
Average	2.45 – 2.55	14	14
Need some work	2.56 – 2.79	79	72
Needs a lot of work	>2.80	7	14

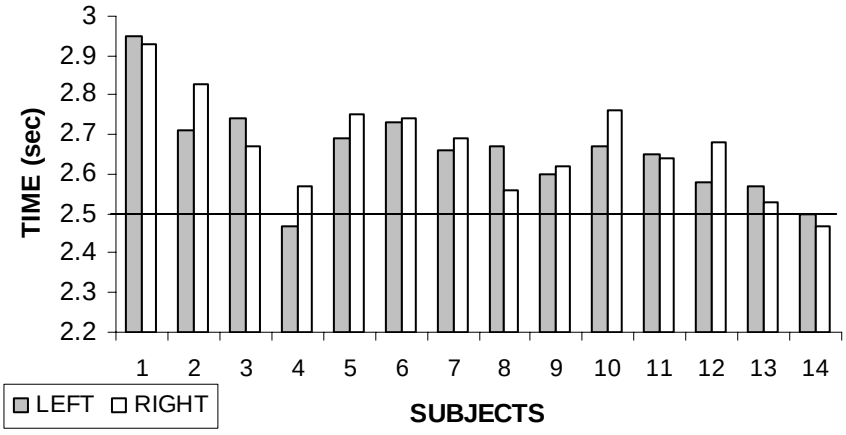


Figure 11. Pre-test results for the 505-agility test.

Muscle Endurance

One-Minute Passing Test

This test measures the muscular endurance of the arms in order to determine if there is sufficient strength and power for activities such as throwing and catching in netball (Figure 12). The group average score for this test was 45.63 ± 1.3 passes. Unfortunately, no norms have been established for this test yet. In our department, an ideal score is considered 60 passes per min, while 40 passes is considered average. This fitness component was therefore not a weak point.

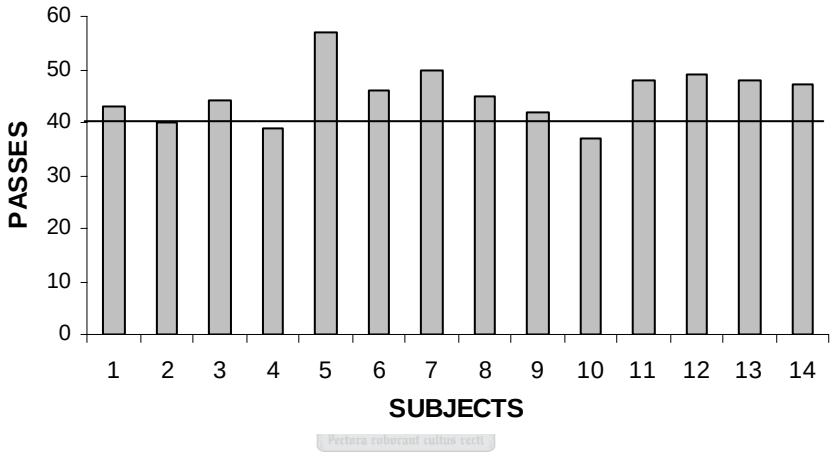


Figure 12. Pre-test results for the one-minute passing test.

Summary of Pre-Test Results

According to the pre-test results, the weaknesses for the majority of players in the experimental group were identified as the flexibility of the hamstring muscles, flexibility of the right leg iliopsoas muscles (Modified Thomas Test), power (Vertical Jump Test), strength (Seven Stage Abdominal Test), speed (20m Sprint Test), agility (505-Agility), anaerobic fitness (Repeated Sprint-Ability) and aerobic fitness (Multistage Fitness Test). Therefore, the customised training programme was designed to specifically address these weaknesses as well as general fitness components.

Pre-Test Comparison of the Experimental and Control Group

Table 10 illustrates the results for the experimental and control groups that were statistically significantly different prior to the intervention programme. On average, the experimental group (N=14) were significantly younger, with an average age of 19.21 ± 0.4 years, while the control group (N=16) had an average age of 21.88 ± 0.8 years (p=0.004). Furthermore, the results for the fitness tests show that the two groups were not on the same level at the beginning of this study. In general, the experimental group who were to follow the customised programme, scored better in the physical fitness tests.

Table 10. Significant Pre-Test Comparisons between the Experimental and Control Group.

	Experimental group			Control group			
Test	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**p-value**
Left Iliopsoas	14	167.71	7.9	16	179.94	5.9	p=0.0001
Vertical Jump	14	40.36	5.8	16	35.28	5.4	p=0.02
Left Agility	14	2.66	0.1	16	2.92	0.2	p=0.0001
5m Speed	14	1.19	0.1	16	1.25	0.1	p=0.03
10m Speed	14	2.02	0.1	16	2.12	0.1	p=0.02
20m Speed	14	3.47	0.3	16	3.72	0.2	p=0.01
Repeated Sprint Ability	14	654.64	45.7	16	616.33	39.8	p=0.02
Estimated VO_2max	14	42.56	6.7	6	35.62	5.3	p=0.03

Effect of the Customised Training Programme

Aerobic Fitness

The results for the Multistage Fitness Test (Bleep Test) are presented in Figure 13, while the estimated VO_{2max} values are shown in Figure 14. According to Figure 13, the experimental group was aerobically more fit than the control group on both the pre- and post-tests. The experimental group improved significantly (17.7%) after the intervention programme (10.00 shuttles ± 1.7), while the control group's performance actually decreased by 4%.

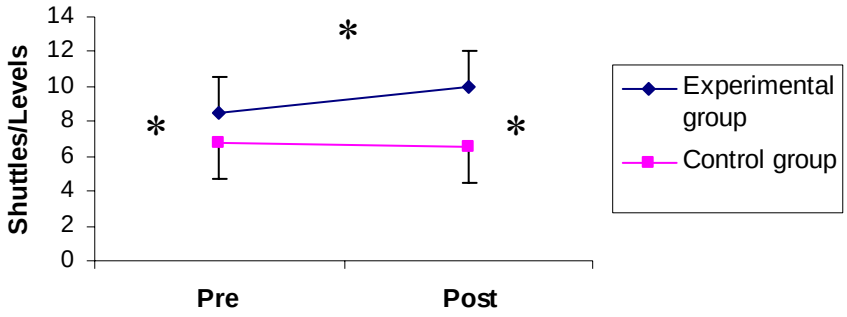


Figure 13. Changes in multi-stage fitness test scores. *p<0.05

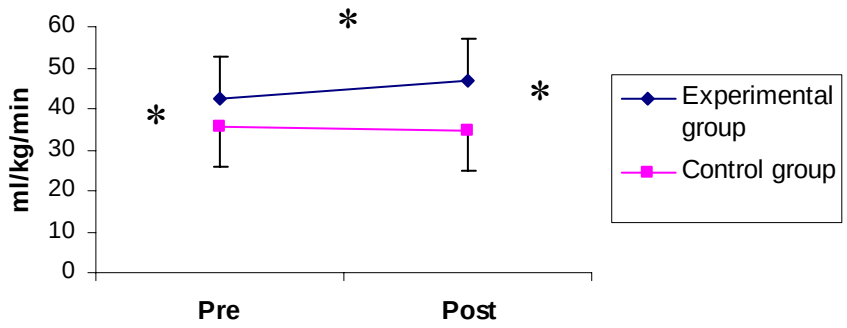


Figure 14. Changes in estimated VO_{2max} values. *p<0.05

As expected, the estimated VO_{2max} values were significantly higher than for the control group on both test occasions ($p<0.05$). Importantly, the experimental group responded positively to the customized training programme and improved their VO_{2max} values by 10% ($p<0.05$).

Anaerobic Fitness

The results of the Repeated Sprint-Ability Test are presented in Table 11. There were statistically significant differences in anaerobic fitness between the experimental and control groups both before and after the intervention. However, the improvement in anaerobic fitness of only 2% in the experimental group was not statistically significant.

Table 11. Pre- and Post-Test Comparisons for Anaerobic Fitness.

Repeated Sprint Ability Test	Pre-testing				Post-testing			
	n	Mean	SD	Range	n	Mean	SD	Range
Experimental group	14	654.64*	45.7	600 - 740	14	665.98*	32.5	620 - 722.5
Control group	16	616.33	39.76	540 - 675	12	618.96	42.16	535 - 710

* Significant differences between the two groups ($p<0.05$).

Power

According to the results of the vertical jump test (Figure 15) the experimental group had significantly more power than the control group on both test occasions. As a result of the intervention programme, the experimental group improved from 40.36 ± 5.8cm to 42.07 ± 6.4cm (0.7%, $p<0.05$), while there was a significant decrease in the performance of the control group after 9 weeks.

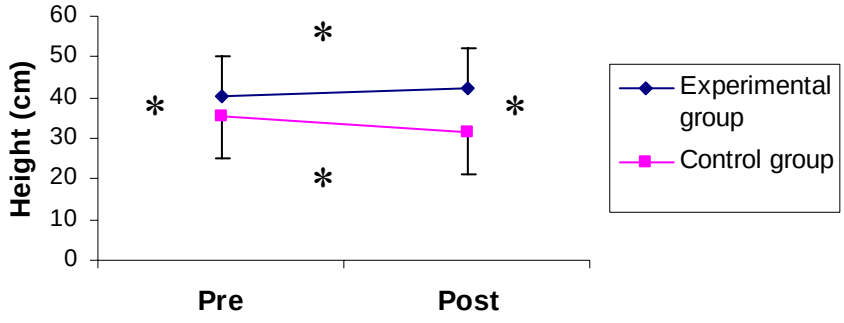


Figure 15. Changes in the vertical jump test scores. *$p<0.05$

Flexibility

Straight Leg Raise Test

Although there was no significant difference between the two groups on the pre-test, the experimental group achieved a significant improvement on the post-test, after completing the customised training programme. This improvement also produced a significant difference when compared with the post-test scores of the control group. The experimental group improved significantly from 70.93 ± 10.9º (left) to 105.57 ± 9.4º and from 71.57 ± 6.9º for the right leg to 99.5 ± 11.1º ($p<0.05$) (Figures 16 and 17).

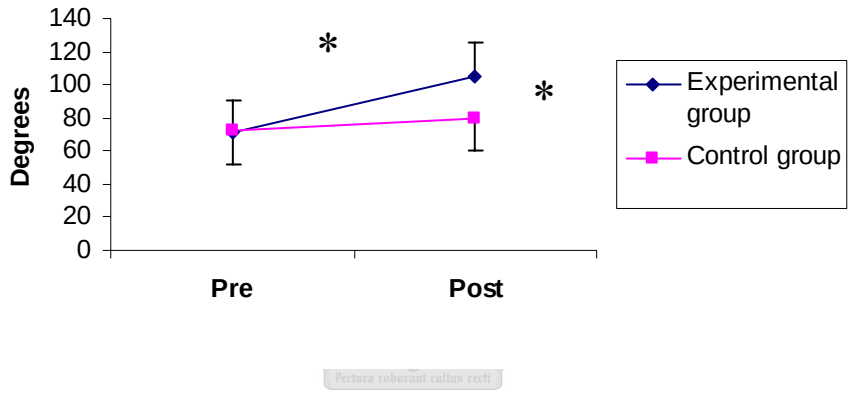


Figure 16. Changes in left hamstring flexibility. *$p<0.05$

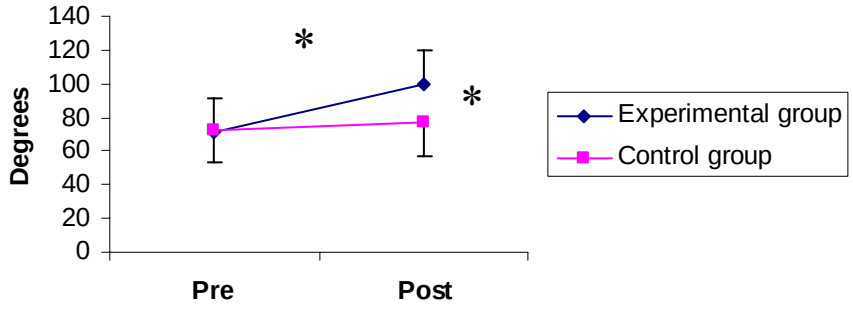


Figure 17. Changes in right hamstring flexibility. *$p<0.05$

Modified Thomas Test

Table 12 presents the results for the Modified Thomas Test. On average, the majority of players in both these groups fell into the category "above average" and there was in reality no need to improve the flexibility of either the quadriceps or the iliopsoas muscle groups. Nevertheless, there was a significant improvement of 8% in left quadriceps muscle flexibility in the experimental group after the intervention programmeme (p=0.02).

Table 12. Pre- and Post-Test Comparisons for the Hamstring and Lower Back Flexibility.

Modified Thomas Test	**Pre-testing**				**Post-testing**			
	n	**Mean**	**SD**	**Range**	**n**	**Mean**	**SD**	**Range**
Experimental group: Quadriceps (left)	14	67.21	10.9	51 - 86	14	72.79*	11.1	50 - 90
(right)	14	68.93	12.9	43 - 86	14	71.36	9.9	49 - 90
Iliopsoas (left)	14	176.71#	7.9	162 - 189	14	180.71	5.7	165 - 189
(right)	14	179.07	6.2	168 - 189	14	176.21	7.3	160 - 190
Control group: Quadriceps (left)	16	70.75	6.4	62 - 82	12	75.00	11.1	52.92
(right)	16	71.56	5.5	61 - 79	12	78.17	10.6	52 - 92
Iliopsoas (left)	16	179.94	5.9	170 - 192	12	181.08	6.7	170 - 195
(right)	16	179.44	6.3	169 - 191	12	176.75	6.6	165 - 189

*Significant difference between pre- and post-test ($p<0.05$).
#Significant difference between experimental and control groups.

Ankle Mobility Test

Table 13 presents the results for the ankle mobility test. On average, both these groups fell into the excellent category and there was no need to improve the flexibility of either the soleus or the gastrocnemius muscle groups. In general there was no significant difference between the groups on the ankle mobility test with pre-testing. The experimental group improved significantly ($p<0.05$) during the 9-week time period when comparing the post-test results with the control group.

Table 13. Pre- and Post-Test Comparisons for Ankle Flexibility.

Ankle Mobility Test	Pre-testing				Post-testing			
	n	Mean	SD	Range	n	Mean	SD	Range
Experimental group: Soleus (left)	14	48.07	5.6	39 - 50	14	45.93	3.6	40 - 55
(right)	14	44.93	4.4	39 - 54	14	46.36	5.1	37 - 56
Gastrocnemius (left)	14	41.14	4.6	32 - 48	14	42.79*	4.2	35 - 49
(right)	14	43.21*	7.9	34 - 66	14	43.79*	3.3	35 - 48
Control group: Soleus (left)	16	47.00	4.46	36 - 54	12	45.17	3.61	40 - 51
(right)	16	44.25	5.98	30 - 54	12	43.75	4.9	37 - 51
Gastrocnemius (left)	16	40.00	4.4	32 - 48	12	37.25	4.27	29 - 46
(right)	16	38.19	5.11	28 - 48	12	38.17	4.95	31 - 49

* Significant difference between the control and experimental group.

Strength

The results for the Seven Stage Abdominal Test are presented in Table 14. Although the experimental group improved by 11.6% after the intervention, this change was not statistically significant. The control group's performance decreased after the 9 weeks.

Table 14. Pre- and Post-Test Comparisons for Strength.

Seven Stage Abdominal Test	Pre-test				Post-test			
	n	Mean	SD	Range	n	Mean	SD	Range
Experimental group	14	3.71	1.3	2 - 6	14	4.14	1.4	2 - 6
Control group	16	3.25	1.4	0 - 5	12	2.33	1.4	0 - 4

Speed

The results of the 20m sprint test are presented in Table 15. Although the experimental group ran faster times after the intervention programme, none of the changes were statistically significant. Surprisingly, the control group also performed better during the post-tests, however, these changes were also not statistically significant.

Table 15. Pre- and Post-Test Comparisons for Speed.

20m Sprint Test	Pre-testing				Post-testing				
	n	Mean	SD	Range	n	Mean	SD	Range	p-value
Experimental group: Speed (5m)	14	1.19	0.8	1.06 - 1.34	14	1.17	0.6	1.03 - 1.24	p=0.36
(10m)	14	2.02	0.1	1.83 - 2.17	14	1.99	0.1	1.8 - 2.12	p=0.33
(20m)	14	3.47	0.3	2.75 - 3.89	14	3.44	0.2	3.08 - 3.79	p=0.74
Control group: Speed (5m)	16	1.25	0.1	1.1 - 1.38	12	1.21	0.1	1.13 - 1.35	p=0.14
(10m)	16	2.12	0.1	1.89 - 2.31	12	2.09	0.1	1.95 - 2.31	p=0.44
(20m)	16	3.72	0.2	3.38 - 4.15	12	3.64	0.2	3.34 - 4.11	p=0.34

Agility

The results of the 505-agility test are presented in Table 16. With both the left and right feet, the experimental group was significantly faster on the pre-test than the control group ($p<0.05$). On average, the experimental group improved by 1% to 2.64 ± 0.2sec (left and right), while the control group improved by 8.6% (left) to 2.67 ± 0.2sec and 5.2% (right) to 2.69 ± 0.2sec. However, there were no significant differences between the 2 groups after the 9 weeks.

Table 16. Pre- and Post-Test Comparisons for Agility.

505 Agility Test	Pre-testing				Post-testing				
	n	Mean	SD	Range	n	Mean	SD	Range	p-value
Experimental group: Agility (left)	14	2.66#	0.1	2.47 - 2.93	14	2.64	0.2	2.42 - 3.04	p=0.44
(right)	14	2.67	0.1	2.47 - 2.93	14	2.64	0.2	2.45 - 2.96	p=0.11
Control group: Agility (left)	16	2.92	0.2	2.68 - 3.25	12	2.67*	0.2	2.46 - 2.98	p=0.0003
(right)	16	2.84	0.2	2.55 - 3.31	12	2.69*	0.2	2.47 - 2.92	p=0.05

* Significant difference between pre- and post-tests ($p<0.05$).
# Significant difference between experimental and control groups ($p<0.05$).

Muscle Endurance

The results for the one minute passing test are presented in Table 15. Although there were an improvement in the performance of the experimental group, this change (2.5%) was not statistically significant. The control group also improved their performance by 2%, but this was also not statistically significant.

Table 17. Pre- and Post-Test Comparisons for Muscle Endurance.

One Minute Passing	Pre-test				Post-test			
Test	**n**	**Mean**	**SD**	**Range**	**n**	**Mean**	**SD**	**Range**
Experimental group	14	45.36	5.2	37 - 57	14	46.5	4.7	37 - 53
Control group	16	43.38	6.3	29 - 51	12	44.25	6.6	30 - 52

Summary

The results indicate that the customised training programme successfully improved netball players' aerobic fitness, leg power and hamstring flexibility. Although there were slight improvements in the other fitness components, the changes were not statistically significant. The results of the experimental group attained the desired results, namely, improvement in all categories although not all were statistically significant. The length of the customised training programme (only 9 weeks) and the sample size of the groups may have affected the outcome of the statistical analysis.

Chapter Five

Discussion, Recommendations and Conclusions

The previous chapter presented data to illustrate the extent to which the customised training programme presented in this study helped netball players achieve improvements in selected physical variables that support netball performance. According to the pre-test results, the weaknesses for the majority of players in the experimental group were identified as the flexibility of the hamstring muscles, flexibility of the iliopsoas muscles (Modified Thomas Test), power (Vertical Jump Test), muscle endurance (Seven Stage Abdominal Test), speed (20m Sprint Test), agility (505-Agility), anaerobic fitness (Repeated Sprint Ability) and aerobic fitness (Multistage Fitness Test). Therefore, the customised training programme was designed to specifically address these fitness components.

The initial differences between the experimental and control groups (left iliopsoas flexibility, flexibility of both gastrocnemius muscles, power, agility, speed, anaerobic fitness and aerobic fitness) at the start of the customised training programme were statistically significant. It was concluded that the two groups were not on the same level of fitness in these components. In general, the results of the experimental group indicated that the customised training programme successfully improved their aerobic fitness, leg power and hamstring flexibility. Although there were slight improvements in the other fitness components, the changes were not statistically significant.

General Findings

Aerobic Fitness

It was reported in Chapter Two of this study that high levels of aerobic fitness in netball are important for successful performance. Woolford et al. (1993) reported that over two thirds of elite netball players run between 3–10 km per week. According to the pre-test results, the aerobic fitness of the experimental group was identified as one of the weaknesses on which the customised programme had to focus. There was a significant difference between the experimental and control group in aerobic fitness at the start of the customised training programme. The aerobic fitness of the experimental group at post-testing showed a improvement. It is concluded that this customised training programme significantly improved the aerobic fitness of the players in the experimental group.

Aerobic fitness was trained within the customised training programme mainly with intervals. Interval training is described by Bishop (2001) as "involving repeated periods of higher intensity exercise interspersed with periods of easier exercise" (p.27), while the recovery time is equal to or shorter than the work bouts to follow. Endurance capacity was further trained by endurance activities such as jogging longer distances (2km, 5km and 8km) at club fitness sessions.

Each training session was divided into a warm-up (long slow distance running), an optional stretching period, dynamic exercises, power training, ball activities, speed and agility training followed by another optional stretching period . The aim was to have repeated periods of higher intensity exercise interspersed with periods of easier exercise, while the recovery time was equal to, or shorter than, the work bouts to follow.

The following was good about the intervention:

- Each training session started with a long distance slow jog as warm-up (± 10min). Jogging sessions were always away from the netball courts to reduce boredom and to train on different surfaces. At each session a different player was identified to take the lead.
- Intensity was increased gradually each week. At the start of the customised training programme the players started with a jog and 3 minute warm-up before the stretching exercises. By the end of the programme, they were jogging for 10 minutes in the warm-up, without any rest, before the stretching exercises started.
- The 9-week period was effective to help improve the players aerobic fitness.
- All the players of the experimental group were not elite netball players. They also competed in other sports and cross training, for example, jogging, cycling and action netball. Therefore, the statistically significant improvement in aerobic fitness can be attributed to the sum of all these activities, and not only to the customised training programme.

Anaerobic Fitness

During a netball game, a player will be required to perform several short sprints, therefore, there is a need for superior anaerobic capacity. In the customised training programme anaerobic fitness was developed through short and high intensity activities. Baker et al. (1993) explained that anaerobic fitness is the ability to successfully perform short, high intensity activities.

The difference between the groups increased throughout the customised training programme. Although the post-test revealed that the experimental group achieved a 2% improvement and the control group only a 0.5% improvement, the differences from pre- to post-testing were still not statistically significant for either group. In other words, there was no improvement in anaerobic fitness as a result of the customised training programme. There may be a number of reasons for this non-significant outcome.

What should have been done differently:

- The customised training programme should have had shorter, high intensity exercises (i.e., more sprints) much earlier in the programme. The programme only included high intensity exercises from session number 10.

- Shorter rest periods in between exercises earlier in the programme, may have ensured that the players maintained high levels of exertion for longer periods.

- Include more anaerobic specific activities into the customised training programme on a high intensity level. The sessions were not specific enough to improve the anaerobic fitness.

Power

Power is the ability of an athlete to convert strength into the ability to improve performance in activities over distance, height, speed or skills. Ferreira (2001) defined power as "the ability to generate force, and a factor that is highly related to successful performance in many sports" (p. 47). The initial difference between the experimental and control group at pre-testing indicated that the two groups were not on the same level in terms of their power at the start of the study. The experimental group showed a significant improvement of 0.7% in power at post-testing. Therefore, it can be concluded that the customised training programme successfully improved the power of the experimental group.

Jumping for height during match play and jumping for height to intercept a ball during match play can be an integral part of a netball game. Therefore leg power is very important. The increase in power as a result of the customised training programme can be attributed to the high intensity power training which was part of each session.

What was good about the intervention:

- At each training session there was a 5-10min intensive power training period, which included dynamic power exercises. Specific exercises included for example, high knees, vertical jumps, tuck jumps, split jumps. Power training was done before speed and agility training, which means that the players were still fresh and energetic.
- The intensity of these exercises was increased on a weekly basis. At the start of the customised training programme only one power exercise was included in the session, and at the end of the programme 10 minutes of the session consisted of high intensity power training.
- Most of these power exercises were created specifically for the netball players. The players commented a lot on the creativeness of the exercises and they enjoyed the fact that the same exercises were not always repeated.
- This customised training programme showed that any activity that used jumping for height activity could improve power.

Strength

Muscle strength is also closely related to muscle endurance. Ferreira (2001) defined strength as "the amount of force that can be exerted by one group of muscles in a single contraction" (p. 41). To emphasise this relationship, Ellis & Smith (2000) identified the Seven Stage Abdominal Test as a graded test for abdominal strength. The post-test results showed that the experimental group improved by 11.6% in the Seven Stage Abdominal Test. However, this improvement was not statistically significant.

It is possible that the difference achieved was due to improvements in core stability that may have occurred naturally during frequent match play. The customised training programme also included some stabilising exercises, with balance control, to increase body strength in each session.

What should be done differently:

- The customised training programme included too few netball-specific exercises which limited the natural muscle endurance (core stability) improvement during the season of match play.
- More match-play will possibly improve the core stabilisers. It should be noted that the abdominal strength of the control group improved significantly with limited training and match play. Similarity, despite the fact that abdominal strength was not considered an important weakness in the experimental group and, therefore, not substantially addressed in the customised training programme, the experimental group still improved by 11.6%.
- More specific strength exercises, for example, seven stage abdominal muscle test, balance exercises, and stabilizing exercises (tripods) can be incorporated to improve abdominal strength.

Flexibility

Kraemer & Gómez (2001) defined flexibility as "the ability to move joints in a needed range of motion depending on the demands of the sport itself" (p. 8). Flexibility is not a general attribute, but is specific to a particular joint or set of joints. It is not necessary for an athlete to have a maximal range of motion in every joint. It is only necessary that the athlete be able to perform the skills of their specific sport with an effective range of motion. Despite the lack of emphasis in the customised programme, flexibility of the hamstring muscle group in both the legs of the experimental group, improved significantly. Netball players should be flexible in the lower body to be able to move comfortably on the court. Biomechanically, the flexibility of the hamstring muscle group plays an important role in the total flexibility of the lower body (Bompa, 1999).

Since flexibility was not identified as a priority for the customised training programme, only enough time for flexibility work was provided within each session so that players in the experimental group could stretch voluntarily for a 2-3min period after warm-up, and again after the completion of the session. The dynamic warm-ups (Appendix C) included some exercises that would have maintained some flexibility for certain muscle groups (for example, the hamstring muscle group should stretch when doing a hurdle step). Therefore, it is concluded that overall flexibility was maintained with the customised training programme except for the hamstring muscle group which improved significantly.

The following was good about the intervention:

- Dynamic warm-ups were used which were different from the normal stretching exercises that usually characterizes warm-up exercises. For example, in general the coach will tell the players to stretch their muscles by sitting down and concentrating on one muscle group at a time. In the customised training programme, dynamic exercises were used, for example, skipping, swinging the arms across the courts length, hurdle steps. With the latter exercise, the player warms-up by doing an active hamstring stretch for both legs and jogs across the court keeping the heart rate and body temperature elevated.
- Dynamic exercises save time because they include a warm-up and stretching period simultaneously.
- The experimental group's flexibility was not considered a weakness from the pre-testing results, but even with the limited emphasis in training, all the muscle groups tested for flexibility did improve, although only the hamstring muscle's improves was statistically significant. It is concluded that although flexibility improve naturally with frequent training, it is still important to spend time on stretching to maintain flexibility.

Speed

Penfold & Jenkins (1996) defined speed as "the ability to move the body or body parts through the required range of motion in the fastest time" (p.24). Acceleration is critical for actions such as getting into the proper playing position, evading an opponent or intercepting a pass, all of which are important requirements of the game (Ellis & Smith, 2000). In this study there were significant differences in the speeds over 5m, 10m and 20m between the experimental and control group on the pre-test results. A possible reason for the difference could be the lack of experience of the control group in performing this test. At the time of baseline testing, it was the first time that the control group performed the speed test, whereas some of the experimental group had previous experience with the test.

In comparison to the norms, the results for the 5m, 10m and 20m distances for the experimental group on the pre-test were poor, which meant that improving speed was included as an aim in the customised training programme. Although there was an improvement in speed over all the distances for both groups on the post-test, the improvements were not statistically significant. This indicated that the customised training programme was not successful in developing speed. However, this result was a surprise finding, since speed training was done specifically with high-intensity and short rest periods.

What should be done differently:

- More speed training in the early stages of the training session together with agility training before the players get fatigued. All the power training was done before the speed and agility at each session. With the start of the customised training programme only one power exercise was included in the training, but as the intensity and volume increased 10 minutes was used for power training. It is possible that during the latter sessions of the customised training programme the players were already fatigued before they started with the speed exercises. They may not have trained at full speed under these circumstances.

- The training sessions were not specific enough on speed training. It is suggested that customised training programs should include more speed-specific exercises and sufficient recovery periods.

- Reaction time at the start of a sprint plays an important role in completing the distance in the fastest time. Good reaction times are thus important for speed over a short distance, and should perhaps be included as separate exercises in customised training programs.

Agility

There are not many sports that require the athlete to sprint only in a straight line. Kraemer & Gómez (2001:7) defined agility as "the ability to stop and change direction quickly". The importance of agility in netball was identified by Ellis & Smith (2000) in terms of the contribution to the basic movements, including different sidewards movements, sudden changes in direction, and quick stops and starts.

Although there was an improvement of agility in both feet on the post-test of the experimental group, the difference between the pre and post-tests was not significant. This indicates that the customised training programme did not significantly improve the agility of the players.

What should be done differently:

- More agility training in the early stages of the training session together with speed training before the players get fatigued. All the power training was done before the speed and agility at each session. With the start of the customised training programme only one power exercise was included in the training, but as the intensity and volume increased 10 minutes was used for power training. It is possible that during the latter sessions of the customised training programme the players were already fatigued before they started with the agility exercises. They may not have trained at full speed under these circumstances.

- The training sessions were not specific enough for agility training. More interval exercises, with changes in direction and sprints, are suggested to improve this aspect of the customised training programme.

Muscle Endurance

Ferreira (2001:44) referred to muscular endurance as "the ability to repeatedly perform sub-maximal muscular contractions". She stated that activities to promote muscular endurance must target specific parts of the body. A netball player needs a certain amount of fitness in relation with muscular endurance to perform at near-maximum effort throughout the game. Muscular endurance is also closely related to muscle strength.

To my knowledge the one-minute passing test was never used before for research purposes with netball players and no sport-specific normative data were available. According to the post-test results, the experimental group improved by 2.5%, but the improvement was not statistically significant.

Although muscle endurance was identified as a weakness, not many activities in the intervention were specifically aimed at muscle endurance. It was assumed that upper body endurance develops through netball-specific exercises, i.e., throwing, catching, and ball activities. As it was agreed with the coach that these exercises will be included in her sessions, the customised training programme only included a few exercises to improve muscle endurance.

What should have been done differently:

- More netball-specific ball activities, as part of the customised training programme, should be included.

- Muscle endurance is not the most critical aspect to ensure successful performance in netball, and with a time limitation on the intervention programme in each training session, only a few minutes in the customised training programme were dedicated to the improvement of muscle endurance.

General Limitations of the Study

1. The inclusion of a university holiday in the 6th week of the 9 week time period made it difficult to control those training sessions. It would be ideal if the programme did not include a "break".
2. The differences in physical fitness between the experimental group and the control group at the start of the study.
3. The number of subjects (experimental and control group) of the present study was a limitation. The data collected at post-testing is insufficient to generate conclusive results. A similar study with more subjects, additional criteria (such as control over participation in post-testing of the control group), and a sample chosen at random would be needed to confirm the results of the present study.

Recommendations

In view of the conclusions drawn as a result of the research, the following recommendations are made.

1. Including adequate trials before the actual testing will minimize the learning-effect.

2. The optimal frequency, intensity and duration of a programme, for example, still need to be established. A fitness trainer would need to have freedom to manipulate the frequency, intensity, and duration of the training sessions within the customised training programme, if it is to be successful.

3. More time available for the customised training programme over all at each training session to do specific exercises for each physical weakness of the team. The coach gave permission for 45 minutes to be used at each training session for the intervention programme.

General there were three positive aspects to the study that deserve mention. The following strategies worked very well:

1. The training session to prepare the test administrators helped to familiarise them with the tests. This training helped them to operate well and efficiently during the data gathering in the pre- and post-test sessions.

2. The supportive involvement of the teams' coaches was helpful, especially with the experimental group. The coach's support and motivation must be regarded as critical to the success of any training programme.

3. Feedback was delivered to each player after each session as a kind of personal physical fitness report (see Appendix D). This information was met with great enthusiasm and appreciation.

Conclusion

The following conclusions were drawn from this study:

- Aerobic and anaerobic fitness are important factors for performance in netball players. Although both aspects improved during this research, only the aerobic fitness improved significantly.

- The flexibility of the hamstring muscle group was the only flexibility test which achieved a significant improvement, however, this happened despite the lack of emphasis in the customised programme.

- Power improved significantly as an outcome of the customised training programme.

- Although there was an improvement in all the physical variables of the experimental group, the results were significant only for the variables mentioned above. It may be possible that a longer and/or more specific customised training programme that focused on only two or three of the weak variables, and more

time available in each training session and for the intervention period could have significantly improved all these variables.

- Although some of the results were not statistically significant, this may be attributed to the small sample size. In reality, any improvement in physical fitness may have a significantly positive effect on performance.

Research on the effectiveness of customised training programmes in the development of physical fitness of netball player's, is very limited. Most previous studies on netball players addressed only the anthropometry of netball players. As netball becomes more technical and professional, competition is getting tougher, and players must train seriously if they hope to achieve top level performance.

Sport science services regarding sports that typically have not received scientific attention in the past, must try to keep-up if they want to contribute to the development of players in these sports. Results like these can set the base for future research and help to improve the understanding of netball.

This study was intended to improve the physical fitness of netball players through specific training in the form of a customised training programme. Although the main focus of the study was to determine the effect of specific training on the netball players, certain limitations regarding the study have been acknowledged. Many of the netball players in South Africa need to improve some of their individual physical skills in order to improve their performance. A player can only improve their physical skills at the top level if they have access to knowledgeable trainers to help them. Coaching netball players can be substantially enriched through the presentation of training programmes that have been customised to address their physical weaknesses, as identified during scientific testing.

References

AMERICAN COLLEGE OF SPORTS MEDICINE. (1995). *ACSM'S Guidelines for exercise prescription and testing*. Baltimore, MD: Williams & Wilkins.

APOSTOLOPOULOS, N. (2001). Performance Flexibility. In B. Foran (ed.), *High-Performance Sports Conditioning (pp. 3-17)*. Champaign, IL: Human Kinetics.

ARNHEIM, D.D. & PRENTICE, W.E. (2000). Principles of Athletic Training. Tenth Edition. Singapore: McGraw-Hill..

BAKER, J.; RAMSBOTTOM, R. & HAZELDINE, R. (1993). Maximal shuttle running over 40m as a measure of anaerobic performance. *British Journal of Sports Medicine*, 27(4):228-232.

BAKER, D. (1996). Improving Vertical Jump Performance through General, Special, and Specific Strength Training: A brief review. *Journal of Strength and Conditioning Research*, 10(2):131-136.

BAQUET, G.; VAN PRAAGH, E. & BERTHOIN, S. (2003). Endurance Training and Aerobic Fitness in Young People. *Sports Medicine*, 33(15):1127-1143.

BELL, W., COOPER, S.M., COBNER, D. & LONGVILLE, J. (1994). Physiological changes arising from a training programme in under-21 international Netball players, *Ergonomics*, 37(1):149-157.

BENEKE, R.; LEITHäUSER, R.M. & HüTLER, M. (2001). Dependence of the maximal lactate steady state on the motor pattern of exercise. *British Journal of Sports Medicine*, 35:192-196.

BISHOP, D. (2001). Aerobic interval training for team sport athletes. *Sports Coach*, 23(4):27-29.

BOMPA, T.O. (1994). *Theory and Methodology of Training*. Third Edition. Toronto: Kendall/Hunt.

BOMPA, T.O. (1999). *Periodization: Theory and methodology of Training.* Fourth Edition. Champaign, IL: Human Kinetics.

BRANDON, R. (2004). Aerobic Interval Training: You can vary the intensity, the work period and the rest period – but which combination is most effective? http://www.pponline.co.uk. 19 June 2004.

BUNC, V. (1994). A simple method for estimating aerobic fitness. *Ergonomics,* 37(1): 159-165.

BUTLER, R. (1996). *Performance Profiling: Audio tape and booklet for coaches and performers*. Headingly, Leeds: The National Coaching Foundation.

CALDER, A. (2000). Some Common Myths and Misconceptions. *Sports Coach*, 22(4): 17-19.

CHANDLER, T.J. (1994). Physiology of Aerobic Fitness/Endurance. *American Academy of Orthopaedic Surgeons*, 43:11-15.

CHANDLER, T.J. (1997). Effect of Moderate and High Intensity Training. *Strength and Conditioning*, December.

CIBICH, B. (1991). Application of Sport Science to hockey. *Sports Coach*, June, 3-6.

CLIFFORD, C. & FEEZELL, R.M. (2000). Respect between players and coach. *Sports Coach*, 23(3):8-9.

COUTTS, A. (2001). Monitoring training in team sports. *Strength and Conditioning*, 24(3):21-23.

DANIELS, J. (2001). Aerobic capacity for Endurance. In B. Foran. *High-Performance Sports Conditioning, (pp. 3-17)*. Champaign, IL: Human Kinetics.

DAMM, G. (1996). Specificity. *Sports Coach*, 19(3):10-11.

DAMM, G. (1997). Overload. *Sports Coach*, 19(4):12-13.

DAVIS, J. (1996). *Fitness for Games Players*. Headingley, Leeds: The National Coaching Foundation.

ELLIS, L. & SMITH, P. (2000). Protocols for the Physiological Assessment of Team Sport Players. In J.C. Gore (ed). *Protocols for the Physiological Assessment of Netball Players, (pp. 302-310)*. Champaign, IL: Human Kinetics.

ELLIS, L. et al. (2000). Protocols for the Physiological Assessment of Team Sport Players. In J.C. Gore (ed). *Physiological tests for elite athletes, (pp. 128-144)*. Champaign, IL: Human Kinetics.

FERREIRA, S. (2001). An instrument to assess the Fitness of Field Athletes with Physical Disabilities. Unpublished Masters (Sport Science) thesis. Stellenbosch: Stellenbosch University.

FLECK, S.J. & KRAEMER, W.J. (1982). The Overtraining Syndrome. *NSCA Journal*, 50-51.

FRY, A.C.; KRAEMER, W.J.; LYNCH, J.M.; TRIPLETT, N.T. & KOZIRIS, L.P. (1994). Does Short-Term Near Maximal Intensity Machine Resistance Training Induce Overtraining? *Journal of Strength and Conditioning Research*, 8(3): 188-191.

GAMBETTA, V. (1997). The Fallacies of Flexibility. *The Strength and Conditioning Journal*, 7(2):7-9.

GRAHAM, J.E.; BOATWRIGHT, J.D.; HUNSKOR, M.J. & HOWELL, D.C. (2003). Effect of Active vs. Passive Recovery on Repeat Suicide Run Time. *Journal of Strength and Conditioning Research*, 17(2):338-341.

GRANT, S.; CORBETT, K.; AMJAD, A.M.; WILSON, J. & AITCHISON, T. (1995). A comparison of methods of predicting maximum oxygen uptake. *British Journal of Sports Medicine*, 29 (3):147-152.

GRANT, J.A.; JOSEPH, A.N. & CAMPAGNA, P.D. (1999). The Prediction of Vo_2 max: A Comparison of 7 Indirect Tests of Aerobic Power. *Journal of Strength and Conditioning Research*, 13(4):346-352.

HARVEY, D & MANSFIELD, C. (2000). Measuring flexibility for performance and injury prevention. In J.C. Gore (ed). *Physiological assessment of human fitness, (pp.87-113).* Champaign, IL: Human Kinetics.

HAWLEY, J. & BURKE, L. (1998). *Peak performance: training and nutritional strategies for sport*. St Leonards, NSW: Allen & Unwin.

HILL, D.W. & SMITH, J.C. (1993). Gender difference in anaerobic capacity: role of aerobic contribution. *British Journal of Sport Medicine*, 27(1):45-48.

HOFFMAN, J.R.; EPSTEIN, S.; EINBINDER, M. & WEINSTEIN, Y. (1999). The Influence of Aerobic Capacity on Anaerobic Performance and Recovery Indices in Basketball Players. *Journal of Strength and Conditioning Research*, 13(4):407-411.

HOWELL, A.K.; GAUGHAN, J.P.; CAIRNS, M.A.; FAIGENBAUM, A.D. & LIBONATI, J.R. (2001). The effect of Muscle Hypoperfusion-Hyperemia on Repetitive vertical Jump Performance. *Journal of Strength and Conditioning Research*,15(4):446-449.

JAVOREK, I. (1987). Methods to enhance Recovery and avoid Overtraining. *NSCA Journal*, 9(3):43-47.

JEUKENDRUP, A.E. & HESSELINK, M.K.C. (1994). Overtraining: what do the lactate curves tell us? *British Journal of Sports Medicine*, 28(4):239-240.

JONES, A.M. & CARTER, H. (2000). The Effect of Endurance Training on Parameters of Aerobic Fitness. *Sports Medicine*, 29(6):373-386.

JOHNSON, B.L. & NELSON, J.K. (1986). *Practical Measurements for Evaluation in Physical Education*. Fourth Edition. Edina: Burgess Publishing.

KEIR, P.J.; JAMNIK, V.K. & GLEDHILL, N. (2003). Technical-Methodological Report: A Nomogram for Peak Leg Power Output in the Vertical Jump. *Journal of Strength and Conditioning Research*, 17(4):701-703.

KOZIRIS, L.P. et al. (1996). Relationship of Aerobic Power to Anaerobic Performance Indices. *Journal of Strength and Conditioning Research*, 10(1):35-39.

KRAEMER, W.J. & GÓMEZ, A.L. (2001). Establishing a Solid Fitness Base. In B. Foran (ed). *High-Performance Sports Conditioning, (pp. 3-17)*. Champaign, IL: Human Kinetics.

KRAEMER, W.J. & NEWTON, R.U. (1994). Training for improved Vertical Jump. *Gatorade Sports Science Institute*, 7(6):1-10.

KUTZER, B. (1995). Volleyball: Strength Training Periodization through Volume Control. *The Strength and Conditioning Journal*, June, 34-39.

LAU, S.; BERG, K.; LATIN, R. W. & NOBLE, J. (2001). Comparison of Active and Passive Recovery of Blood Lactate and Subsequent Performance of Repeated Work Bouts in Ice Hockey Players. *Journal of Strength and Conditioning Research*, 15(3): 367-371.

LUEBBERS, P. E. et al. (2003). Effects of Plyometric Training and Recovery on Vertical Jump Performance and Anaerobic Power. *Journal of Strength and Conditioning Research*, 17(4):704-709.

MANNERS, T.W. (2004). Sport-Specific Training for Ice Hockey. *Strength and Conditioning Journal*, 26(2):16-21.

MAYHEW, J.L.; BEMBEN, M.G.; ROHRS, D.M. & BEMBEN, D.A. (1994). Specificity among Anaerobic Power Tests in College Female Athletes. *Journal of Strength and Conditioning Research*, 8(1):43-47.

PENFOLD, L. & JENKINS, D. (1996). Training for Speed. In P. Reaburn & D. Jenkins (ed.) *Training for Speed and Endurance, (pp. 24-41)*. St Leonards, NSW: Allen & Unwin.

PIPER, T.J. (1997). In-Season Strength/Power Mesocycle for Women's Collegiate Volleyball. *Strength and Conditioning*, June.

PLOWMAN, S.A. & SMITH, D.L. (1997). *Exercise Physiology for Health, Fitness, and Performanc*e. Needham Heights: Allyn and Bacon.

POTGIETER, J.R. (1997). Sport psychology. University of Stellenbosch. Institute of Sport- and Movement study University of Stellenbosch.

PYNE, D. (1997). Developing endurance fitness. *Sports Coach*, Autumn.

PYNE, D. (2002). Simple fitness testing for individual and team sports. *Sports Coach*, 24(4):10-11.

RADCLIFFE, J. C. (1994). A Power Perspective. *Strength and Conditioning*, October, 46-47.

REABURN, P. (1998). Tapering. *Sports Coach*, 21(3):30-31.

REABURN, P. & COUTTS, A. (2000). Concurrent sprint, strength and endurance training. *Strength and Conditioning*, 23(3):22-23,

RHEA, M.R.; BALL, S.D.; PHILLIPS, W.T. & BURKETT, L.N. (2002). A Comparison of Linear and Daily Undulating Periodized Programs with Equated Volume and Intensity for Strength. *Journal of Strength and Conditioning Research*, 16(2):250-255.

RHEA, M.R. et al. (2003). A Comparison of Linear and Daily Undulating Periodized Programs with Equated Volume and Intensity for Local Muscular Endurance. *Journal of Strength and Conditioning Research*, 17(1):82-87.

ROWLAND, T.W. (1996). *Developmental Exercise Physiology*. Champaign, IL: Human Kinetics.

RUTLEDGE, I. & FACCIONI, A. (2001). Dynamic warm-ups. *Sports Coach*, 24(1): 20-22.

SCHILLING, B.K. (2000). Stretching: Acute Effects on Strength and Power Performance. *Strength and Conditioning Journal*, 22(1):44-47.

SINNETT, A.M.; BERG, K.; LATIN, R.W. & NOBLE, J.M. (2001). The Relationship Between Field Tests of Anaerobic Power and 10-km Run Performance. *Journal of Strength and Conditioning Research*, 15(4):405-412.

SOUTH AFRICAN SPORTS COMMISSION. (2002a). *DISSA general testing*. Unpublished data. Centurion: South African Sports Commission.

SOUTH AFRICAN SPORTS COMMISSION. (2002b). *Netball Protocol*. Section 36. DISSA general testing. Unpublished data . Centurion: South African Sports Commission.

SPORER, B.C. & WENGER, H.A. (2003). Effects of Anaerobic Exercise on Strength Performances following various Periods of Recovery. *Journal of Strength and Conditioning Research*, 17(4):638-644.

SPROULE, J.; KUNALAN, C.; McNEILL, M. & WRIGHT, H. (1993). Validity of 20-MST for predicting $Vo_{2\,max}$ of adult Singaporean athletes. *British Journal of Sports Medicine*, 27(2):202-204.

STONE, M.H.; KEITH, R.E.; KEARNEY, J.T.; FLECK, S.J.; WILSON, G.D. & TRIPLETT, N.T. (1991). Overtraining: A Review of the Signs, Symptoms and Possible Causes. *Journal of Applied Sport Science Research*, 5(1):35-50.

STONE, M.H.; PIERCE, K.C.; HAFF, G.G.; KOCH, A.J. & STONE, M. (1999a). Periodization: Effects of manipulating Volume and Intensity. Part 1. *Strength and Conditioning Journal*, 21(2):56-62.

STONE, M.H.; PIERCE, K.C.; HAFF, G.G.; KOCH, A.J. & STONE, M. (1999b). Periodization: Effects of manipulating Volume and Intensity. Part 2. *Strength and Conditioning Journal*, 21(3):54-60.

TOMLIN, D.L. & WENGER, H.A. (2001). The Relationship between Aerobic Fitness and Recovery from High Intensity Intermittent Exercise. *Sports Medicine*, 31(1): 1-11.

UNKNOWN. (2000). Testing for aerobic capacity. *Sports Coach,* 23(2):18.

UYS, S.M. (2001). The Use of Computerised Games Analysis to Identify Critical Indicators of Success in Elite Level Netball. Unpublished Masters (Sport Science) thesis. Stellenbosch: Stellenbosch University.

VAN BORSELEN, F.; VOS, N.H.; FRY, A.C. & KRAEMER, W.J. (1992). The role of anaerobic exercise in overtraining. *National Strength and Conditioning Association Journal*, 14(3):74-78.

VINCENT, W, J. (1999). *Statistics in Kinesiology*. Second Edition. Champaign, IL: Human Kinetics.

WALD, T. (1998). Norma Plummer: Team Coach of the Year (Female: 1997). *Sports Coach*, Summer, 4-6.

WALLACE, W. (2002). The women who made girls jumps. *London: Times Newspapers*, 26 April, 12-15.

WELLS, C.L. (1991). *Women, Sport, & Performance: A Physiological Perspective.* Champaign, IL: Human Kinetics.

WILMORE, J.H. & COSTILL, D,L. (1993). Training for Sport and Activity: The Physiological basis of the Conditioning Process. Third edition. Champaign, IL: Human Kinetics.

WINCH, M. (2004). How strong do your athletes need to be? *Brian Mackenzie's Successful Coaching*, 11 April, 1-2.

WOOLFORD, S. & ANGOVE, M. (1991). A Comparison of Training Techniques and Game Intensities for National Level Netball Players. *Sports Coach*, December.

WOOLFORD, S.; BOURDON, P.; CRAIG, N. & STANEF, T. (1993). Body composition and its effects on athletic performance. *Sports Coach*, 16:24-30.

YESSIS, M. (1994). Training for Power Sports-Part 1. *Strength and Conditioning*, October, 42-45.

YOUNG, W. (1991). Plyometrics for Netball. *Sports Coach*, October-December.

Appendix A

CONSENT FORM

NAME: …….. **DOB:** …….

TEL: ……

ADRESS: ……

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 program 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 of any existing medical condition/other complaint or injury that would preclude me from full participation in the testing.
- I give my written consent to the Stellenbosch Sport Science Centre to conduct the battery of tests.
- I indemnify the Stellenbosch Sport Science Centre 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.

Athlete's signature:……..
Date:…….

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

Tester's signature:……..
Date:…….

Appendix B

RESULT SHEET

MATIES NETBALL TESTING

Name: _____ Position: _____

Date of Birth _____ Age: _____

FLEXIBILITY

Straight leg raise

Left: _____ Right: _____

Modified Thomas

Test	**Left**	**Right**
Quads		
Iliopsoas		

Ankle

Test	**Left**	**Right**
Soleus		
Gastrocnemius		

MUCLE ENDURANCE

One minute passing

_____/min

POWER

Vertical jump

Stand and reach height: _____cm

Best height _____cm

Difference: _____ cm

Trial 1: _____cm

Trial 2: _____cm

Trial 3: _____cm

STRENTGH

7 Stage Abdominal Test

Score: _____

SPEED

5, 10, 20m Sprint (standing start)

Trail 1: 5m: _____sec 10m_____sec 20m: _____sec

Trail 2: 5m: _____sec 10m_____sec 20m: _____sec

AGILITY

Netball agility test

Dominant:	**Left**	**Right**
Trial 1		
Trial 2		

ANAEROBIC ENDURANCE

Repeated Sprint ability

Distance: _____

Trail 1:_____ Trail 2:_____ Trail 3:_____

Trail 4:_____ Trail 5:_____ Trail 6:_____

AEROBIC ENDURANCE

Multistage shuttle run

Stage: _____ Shuttle: _____ Estimated VO_2max:_____

Appendix C

TRAINING SESSIONS

Session 1: Pre testing

EXERCISES	SETS	TIPS
Pre-tests		
Sign consent forms		
Resting heart rate	3min	Lie on back
Weight		Only for Polar
Height		Only for Polar
Flexibility		
Ankle mobility test	4x	Both legs
Straight leg raise test	2x	Both legs
Modified Thomas test	4x	Both legs
Strength		
Seven stage abdominal test	1x	
Power		
Vertical Jump	3x	Dominant leg
Warm-up	5-10min	Each player
Agility		
Netball agility test	4x	Both feet twice
Muscle Endurance		
One minute passing test	1x	Only chest passes
Speed		
5, 10, 20m sprint	2x	As fast as possible
Anaerobic fitness		
Repeated sprint ability	1x	Pace yourself
Notes: Each player had done all the tests as pre tests in this particular procedure.		

Session 2: Post-testing

EXERCISES	SETS	TIPS
Pre test		
Aerobic fitness		
Bleep test	1x	Pace yourself
Notes: All the players completed the bleep test as part of the pre-testing		

Session 3 to 21: Customised Training

This is the original 19 sessions as planned before starting with the study. As the sessions continued in the programme a few changes were made (*italics*).

Session 3

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	5min	Slowly
Stretching	2-3min	Optional
Calfs: On the toes (swings arms forward)	Court 2x	Feel the calf muscles
Hamstrings: Hurdle steps (keep arms in front)	Court 2x	Straighten knee
Quads and Glutes: Squads	Court 2x	Go low
Lines in repeated sprint formation	2x	Space yourself
Skipping	Court 2x	
High knees	Court 2x	
Straight legs	Court 2x	
Kick buts	Court 2x	Touch butt
Sprint	Court length	90%
Ball activities: dodge, ball handling, coordination		Coach's activities
Stretching	2 - 5min	Legs especially
Notes: The session went according to plan with all the players present.		

Session 4

EXERCISES	SETS	TIPS
Warm-up: jogging for 5min. (50%)		Slowly
Stretching	2-3min	Optional
Skipping	2 x 20m	
High knees	2 x 20m	
Straight legs	2 x 20m	
Kick buts	2 x 20m	Touch butt
Run 70% 20m and jog back		
Hurdle steps (both legs)	2 x 2 x 20m	Keep hips straight
Vertical jumps (both legs)	2 x 2 x 20m	Use arms to jump as high as possible
On the toes	2 x 20m	Feel the calve muscles
Lunges	2 x 20m	Knee not over toe
Run 70% 20m and jog back	2 x	
Sprints 90% 20m	5x on 30sec	Commitment
Stretching	5 – 10min	Legs especially
Notes: The session went according to plan with all the players present.		

Session 5

EXERCISES	SETS	TIPS
Warm-up: jogging for 5min. (50%)		
Stretching	2-3min	Optional
Skipping	2 x 20m	
High knees	2 x 20m	
Straight legs	2 x 20m	
Kick buts	2 x 20m	Touch butt
Run 70% 20m and jog back		
Hurdle steps (both legs)	2 x 2 x 20m	Straighten knee
Out swings (both legs)	2 x 2 x 20m	Feel the adductors
Spidermans	2 x 20m	Stay low as possible
Squads	2 x 20m	No knees over toes
Run 70% 20m and jog back	2 x	
Sprints 90% 20m	5x on 30sec	Commitment
Stretching	5 – 10min	Legs especially
Notes: Because of intervarsity at the university the next day there was only 30min and therefore the 20m distance was increased to 25m but sets were decreased to a single for each exercise.		

Session 6

EXERCISES	SETS	TIPS
Warm-up: Running	5min	Slowly
Stretching	2-3min	Optional
High knee hops (both legs)	2 x 2/3	Stretch the body
Hurdle steps (both legs)	2 x 2/3	
On the toes with quads	2 x 2/3	
Outswings	2 x 2/3	Feel the adductors
Sprints 90% 20m	3x on 30sec	
Stretching	2 – 5min	Legs especially
Notes: Short session because they played a practice match/game against other two Maties teams as part of their training. The session went according to plan with all the players present.		

Session 7

EXERCISES	SETS	TIPS
Warm-up: Running	5min	Slowly
Stretching	2-3min	Optional
Skipping	2/3	
High knees	2/3	
Straight legs	2/3	
Kick buts	2/3	
Run 70% 2/3 and jog back	2x	
High knee hops (both legs)	2 x 2/3	Stretch the body
Grapevine (both legs)	2 x 2/3	Keep hips straight
Vertical jumps	2 x 2/3	
Line jumps	2 x 30sec	Fast feet
Run 70% 2/3 and jog back	2 x	
Stretching	2 – 5min	Legs especially
Notes: Another short session because players did played a game the evening before and was tired. Three players were absent for different reasons and two had light injuries therefore did not train. The rest of the players followed the session according to plan.		

Session 8

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	5min	
Stretching	2-3min	Optional
Skipping	2/3	
High knees	2/3	
Straight legs	2/3	
Kick buts	2/3	
Run 70% 2/3 and jog back	2x	
Hurdle steps (both legs)	2 x 2/3	Stretch the body
Vertical jumps (both legs)	2 x 2/3	Keep hips straight
On the toes	2 x 2/3	
Lunges	2 x 2/3	Knee not over toes
Run 70% 20m and jog back	2 x	
Sprints 90% 20m	6x on 30sec	
Stretching	2 – 5min	Legs especially
3 Activities		
Notes: The session went according to plan with two players not present. These players were not present for different reasons (on had a test and the other sick).		

Session 9

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	10min	Do not kill yourself is a warm-up
Stretching	5 min	Optional
Skipping	30 tree (2x)	Stretch your legs
High knees	30 tree (2x)	Knees as high as possible
Straight legs	30 tree (2x)	
Kick buts	30 tree (2x)	Heels need to touch but
Sprint at 70% 30m and run back	2x	Quicker than normal running
Hurdle steps (both legs)	30 tree (2x)	Stretch front leg
Vertical jumps (both legs)	30 tree (2x)	Keep hips straight forward
On the toes	30 tree (2x)	
Lunges	30 tree (2x)	Knee not over toes
Sprint at 70% 30m and run back	2x	Quicker than normal running
Sprints 90% 30m	6x op 30sek	Intervals
Stretching	2 – 5min	Especially legs
Notes: The session went according to plan with 6 players present. This was the first of the 2 holiday sessions with 8 players present (sessions scheduled for those who did not go home the holidays).		

Session 10

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	3min run 1min walk 3min run 1min walk 3min run	Do not kill yourself it's a warm-up
Stretching	5 min	Optional
Hurdle steps (both legs)	30m (2x)	Stretch your strides
Out swings (both legs)	30m (2x)	
Spidermans	30m	Keep hips as low as possible
Squads	30m (2x)	Knees not over toes
Sprint at 70% 30m and run back	2x	Quicker than normal running
Rest	2min	Drink some water
Sprint 70% and run back slowly	30m (2x)	Quicker than normal running
Sprint 90% and run back slowly	30m (2x)	Almost sprint
Sprint 100% and runback slowly	30m (2x)	As fast as possible
Stretching	5 – 10min	Especially legs
Notes: The session went according to plan with all the players present. This was the second of the 2 holiday sessions with 8 players present. Session took a bit too long therefore the cool-down run was not done.		

Session 11

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	5min	
Stretching	2-3min	Optional
Skipping	2/3	
High knees	2/3	
Straight legs	2/3	
Kick buts	2/3	
Run 70% 2/3 and jog back	2x	
Hurdle steps (both legs)	2 x 2/3	Stretch the front leg
Out swings (both legs)	2 x 2/3	Keep hips straight
Spidermans	2 x 2/3	Keep low
Squads	2 x 2/3	Knees not over toes
Run 70% 20m and jog back	2 x	
Sprints 90% 20m	6x on 30sec	
Stretching	2 – 5min	Legs especially
Notes: The session went according to plan with only one player not present, because of work responsibilities. With the last planned activity which was 3 ball activities the coach asks for time to speak with the players therefore the activities was cancelled.		

Session 12

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	10min	Take it slowly
Stretching	2-3min	Optional
Vertical jumps	Court length	Stretch the body
Lunges		Knees not over toes
Tuck jumps	Court length	High knees
Side lunges		Knees not over toes
Squads		Knees not over toes
Walking lunges	Court length	Knees not over toes
Sprint 70% court length and jog back	2x	
Hurdle steps (both legs)	Court length	Stretch the front leg
Out swings (both legs)	Court length	Keep hips straight
Spidermans (both legs)	10 x	Keep low
On the toes	Court length	
Ankle rolls		No pain
Sprint 70% court length and jog back	2x	
Agility activity (each player 2x)	10min	
Lines activity – repeated sprint ability	*2x*	*Sprint forward/Jog backwards always.*
Sprints 90% court length	6x on 30sec	
Balance and Speed activity (each player 2x)	5min	Legs especially
Stretching	2 – 5min	Especially legs
Notes: All the players were present at practice although two did not train because of sickness. The session did go according to plan. The group was loud and difficult to get there attention, therefore the coach ask for a fitness activity (an activity in the repeated sprint ability formation was done).		

Session 13

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	10min	Take it slowly
Stretching	2-3min	Optional
Vertical jumps	Court length	Stretch the body
Lunges	20x	Knees not over toes
Squads	20x	Knees not over toes
Slit lunges	10x	Knees not over toes
Split squads	10x	Knees not over toes
Sprint 70% court length *10sec then run back*	2x	
Skipping	Court length	Stretch the front leg
Straight legs	Court length	
Butt kicks	Court length	
High knees	Court length	
Jump and turn around	Court length	
Sprint 70% court length ~~and jog back~~ *10sec rest then run back*	2x	
Agility activity (each player 2x)	10min	
Lines activity – repeated sprint ability	*2x*	*Sprint forward and jog backwards always.*
Sprints 90% court length	6x on 30sec	
Balance and Speed activity (each player 2x)	5min	Legs especially
Stretching	2 – 5min	Especially legs
Notes: Three players not present. Two with valid reasons the other no excuse just not at practice. Because of the high intensity dynamic exercise and the fact that all the players felt tired the sprint activities change (short rest period before running back to line for next sprint). On request of the coach the repeated sprint activity of the session before was brought in again after the agility activity.		

Session 14

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	7min	Take it slowly
Stretching	2-3min	Optional
Vertical jumps	Court length	Stretch the body
On the toes	Court length	
Tuck jumps	Court length	High knees
Split lunges	10x/leg	Knees not over toes
Squads	Court length	Knees not over toes
Split squads	10x	Knees not over toes
Sprint 80% court length *10sec rest and then jog back*	2x	
Activity 1: Over line (30sec fast feet, sprint 5m forward, vertical jump 3x and jog back.	3x	Put everything in
High knee hops (both legs)	Court length	Height is important
Grapevine (both legs)	Court length	
Hurdle steps with ball (2 player together)	Court length	
Jump throws with ball	2x 20sec	
Balance: one leg stance and receive ball (both legs)	1 min	Keep balance
Sprint 80% court length *10sec rest and then jog back*	2x	
Activity 2: Lines sprint forward run backwards back.	2x	As fast as possible
Sprints 100% court length	5x on 30sec	
Stretching	2 – 5min	Especially legs
Notes: Five players were not able to practice. Two of them not at the training and the other three sick. The only change in the planned session was giving the players a short rest after the sprinting for the reason that the intensity increased from the session before and the athletes felt tired from the weeks training.		

Session 15

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	7min	Take it slowly
Stretching	2-3min	Optional
Hurdle steps (both legs)	Court length	Stretch the front leg
Out swings (both legs)	Court length	Keep hips straight
Spidermans (both legs)	10 x	Keep low
On the toes	Court length	
Ankle rolls	1min	No pain
Sprint 80% court length *10sec rest then jog back*	2x	
Sprint with ball 2 players ~~3x~~ *4x court length*	Court length	Fast
High knees with arms forward	Court length	Knees high
Straight legs with arms swinging forward	Court length	
But kicks with arms swinging backward	Court length	
Hurdle steps (both legs) with arms in air	Court length	Straight leg
Sprint 80% court length *10 sec rest then jog back*	2x	
Activity 1: Over line (30sec fast feet, sprint 5m forward, vertical jump 3x and jog back.	3x	Put everything in
Activity 2: Lines sprint forward run backwards back.	2x	As fast as possible
Sprints 100% court length	5x on 30sec	
Stretching	2 – 5min	Especially legs
Notes: All the players felt tired from the weeks training and it was hard to motivate them. Three players was not at training for different reasons and 4 players did train but did not feel well, the reasons vary from a stomach bug, stiff back and hungry. Again the sprinting activities were change to a short rest before running back for the next sprint. After the first group of dynamic exercises the coach and trainer decide to do the two netball specific exercises before the end and therefore Activity 1 was shift and complete just before Activity 2 at the end of the training.		

Session 16

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	8min	Take it slowly
Stretching	2-3min	Optional
Vertical jumps	Court length	Stretch the body
On the toes	Court length	
Tuck jumps	10x	High knees
Split lunges	10x/leg	Knees not over toes
Squads	10x	Knees not over toes
Split squads	10x	Knees not over toes
Sprint 80% court length and jog back *rest of 20sec between sprints*	3x	
Activity 1: Balance – bent to a lunge position then fast feet left, middle, right in that position.	3x 15sec Each side/leg Then together	Stay low and keep balance
Sprint with ball 2 players ~~3x~~ *4x*	Court length	Fast
High knees with arms forward	Court length	Knees high
Straight legs with arms swinging forward	Court length	
But kicks with arms swinging backward	Court length	
Hurdle steps (both legs) with arms in air	Court length	Straight leg
Sprint 80% court length and jog back *rest of 20sec between sprints*	3x	
Activity 2: Tuck jumps 5x then agility T end with Split jumps 5x.	3x	Jumps as high as possible. Speed and agility NB.
Sprints 100% court length	4x on 25sec	
Stretching	2 – 5min	Especially legs
Notes: Three players sick for different reasons. All the players present felt well after the weeks before tiredness and ready to train. The session planned was change again at sprinting activities with a 20sev rest period between the sprints. Also the sprint with the ball activity at the start of second group dynamic exercise activities was increased too 4 times, for the reason that the players drop the ball too much with the first two (they did not concentrate). The players enjoyed Activity 2 a lot although it was hard.		

Session 17

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	8min	Take it slowly
Stretching	2-3min	Optional
Hurdle steps (both legs)	Court length	Stretch the front leg
Out swings (both legs)	Court length	Keep hips straight
Spidermans (both legs)	10 x	Keep low
On the toes	Court length	
Ankle rolls		No pain
Sprint 80% court length and jog back	3x	
Activity 1: Balance – bent to a lunge position then fast feet left, middle, right in that position.	3x 15sec	Stay low and keep balance
High knee hops (both legs)	Court length	Height is important
Spiderman (both legs)	Court length	
Hurdle step	Court length	
Jump throws with ball		
Balance: one leg stance and receive ball (both legs)	1 min	Keep balance
Sprint 80% court length and jog back	3x	
Activity 2: Tuck jumps 5x then agility T end with Split jumps 5x.	3x	Jumps as high as possible and speed n agility NB.
Sprints 100% court length	4x on 25sec	
Stretching	2 – 5min	Especially legs
Notes: The session did go according to plan with all the players present. They all felt well and trained without complaints.		

Session 18

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	*8min*	Take it slowly
Stretching	2-3min	Optional
Vertical jumps	Court length	Stretch the body
Split jumps	Court length	
Tuck jumps	Court length	High knees
Split lunges		Knees not over toes
Split squads		Knees not over toes
Sprint 80% court length	2x on 15sec	
Activity 1: Balance – bent to a lunge position then fast feet left, middle, right in that position.	3x 15sec Each leg/both sides	Stay low and keep balance
High knee hops (both legs)	Court length	Height is important
Spiderman (both legs)	10/leg	
Hurdle step	Court length	
Jump throws with ball	10x/rest 30sec/10x	
Balance: one leg stance and receive ball (both legs)	1 min	Keep balance
Sprint 80% court length	2x	
Activity 2: Tuck jumps 5x then agility T end with Split jumps 5x.	3x	Jumps as high as possible and speed n agility NB.
Sprints 100% court length	*4x on 25sec*	
Stretching	2 – 5min	Especially legs
Notes: Two changes were made on the planned session the warm-up run was increased from 7min to 8min because players felt tired and it was decide to decrease the intensity but increase the work done with more rest periods between activities. The second change was with the sprints the players felt very stiff and tired and it was decide to decrease the amount of sprints. Players were stiff from fitness the day before. Only one player was not at the training she was competing in the senior trials for Western Province team. Six of the present players did not complete the sprints 100% because they felt tired.		

Session 19

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	8min	Take it slowly
Stretching	2-3min	Optional
Sprint with ball 2 players 3x	Court length	Fast
High knees with arms forward	Court length	Knees high
Straight legs with arms swinging forward	Court length	
But kicks with arms swinging backward	Court length	
Hurdle steps (both legs) with arms in air	Court length	Straight leg
Sprint 80% court length and jog back	3x	
Activity 1: Lines in repeated sprint order and direct after the same in backward formation.	2x	Give it your best
Spiderman (both legs)	Court length	
Hurdle step	Court length	
On the toes (both legs)	10 x	
Jump throws with ball		
Balance: one leg stance and receive ball (both legs)	1 min	Keep balance
Sprint 80% court length and jog back	3x	
Activity 2: Tuck jumps 5x then agility T end with Split jumps 5x.	3x	Jumps high as possible.
Sprints 100% court length	4x on 25sec	
Stretching	2 – 5min	Especially legs
Notes: One of the groups played a game in Wellington as part of the league, therefore only 7 players were at training and one of these players was 20min late for training. The session did go according to plan.		

Session 20

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	10 min	Take it slowly
Stretching	2-3min	Optional
Vertical jumps	Court length	Stretch the body
On the toes	Court length	
Tuck jumps	10x	High knees
Split lunges	10x	Knees not over toes
Squads	10x	Knees not over toes
Split squads	10x	Knees not over toes
Sprint 80% court length and jog back	2x on 15sec	
Activity 1: 1, 2, 3 tips then land	Court length (2x)	Keep your balance
Spiderman (both legs)	10x/leg	
Hurdle step	Court length	
High knee hops	Court length	
Jump throws with ball		20x/rest 30sec/20x
Balance: one leg stance and receive ball (both)	1 min	Keep balance
Sprint 80% court length and jog back	2x	
Activity 2: Tuck jumps 5x then agility T end with Split jumps 5x.	2x	Jumps high as possible.
Activity 3: Square – 1/3 court – push ups, burpees, star jumps, sit ups. Sprint from corner to next corner.	30sec (2x with 2min rest in between)	Give it your best
Activity 4: Ball handling – 1/3 court – shoulder passes, step closer, chest passes, step closer high ball above head.	10 passes/ kind	After each type of pass turn around and sprint to line.
Sprints 100% court length	4x on 25sec	
Stretching	2 – 5min	Especially legs
Notes: The coach was not at the training. There was good atmosphere at training session. One player was sick and two others did not train because their shins were sore. Only one thing was change from original planned session. At the second group of dynamic exercises the activity On the toes was change to High knee hops, to keep the intensity high for the next activity.		

Session 21

EXERCISES	SETS	TIPS
Warm-up: jogging (50%)	10 min	Take it slowly
Stretching	2-3min	Optional
Hurdle steps (both legs)	Court length	Stretch the front leg
Out swings (both legs)	Court length	Keep hips straight
On the toes	Court length	
Ankle rolls		No pain
Sprint 80% court length and jog back	2x on 10sec	
Activity 1: 1, 2, 3 tips then land	Court length	Keep your balance
Sprint with ball 2 players 4x	Court length	Fast
High knees with arms in the air	Court length	Knees high
Straight legs with arms swinging backward	Court length	
But kicks with arms swinging forward	Court length	
Sprint 80% court length and jog back	2x on 10sec	
Activity 3: Square – 1/3 court – push ups, burpees, star jumps, sit ups. Sprint from corner to next corner.	30sec (2x with 2min rest in between)	Give it your best
Activity 4: Ball handling – 1/3 court – shoulder passes, step closer, chest passes, step closer high ball above head.	20 passes/ kind	After each kind of pass turn around and sprint to line.
Sprints 100% court length	4x on 25sec	
Stretching	2 – 5min	Especially legs
Notes: Coach not at training. All the players were at the training, although 3 did complain of not feeling well they did train. It was decided to take out two activities from the session to give the captains more time to talk to teams about the game (within 2 days).		

Session 22

EXERCISES	SETS	TIPS
Post-testing		
Singh consent forms		
Resting heart rate	3min	Lie on back
Flexibility		
Ankle mobility test	4x	Both legs
Straight leg raise test	2x	Both legs
Modified Thomas test	4x	Both legs
Strength		
Seven stage abdominal test	1x	
Power		
Vertical Jump	3x	Dominant leg
Warm-up	5-10min	Each player
Agility		
Netball agility test	4x	Both feet twice
Muscle Endurance		
One minute passing test	1x	Only chest passes
Speed		
5, 10, 20m sprint	2x	As fast as possible
Anaerobic fitness		
Repeated sprint ability	1x	Pace yourself
Notes: All the players did complete this part of the post-tests.		

Session 23

EXERCISES	SETS	TIPS
Post-testing		
Aerobic fitness		
Bleep test	1x	Pace yourself
Notes: All the players did complete this part of post-tests.		

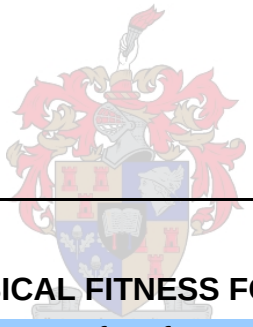
Appendix D

POST FITNESS REPORT

MATIES

5 & 6

2004



IMPORTANCE OF PHYSICAL FITNESS FOR NETBALL PLAYERS

Fitness is an integral component of performance. As fatigue develops, skill deteriorates. Being fit delays the onset of fatigue. Therefore, optimal fitness levels will enable netball players to concentrate for longer time periods, to play at their optimal for the whole game and to have the edge above less fit opponents. Fitness plays also a roll in injury prevention. Those players possessing adequate levels of strength, endurance and flexibility in the muscle groups use in netball, not only enhance their potential to perform better, but also may reduce their susceptibility to injury. Testing provides a coach with information of where an individual's strengths and weaknesses lie in relation to various components of fitness important to netball, as well as providing a measure of progress in response to prescribe training programs.

FLEXIBILITY

The ability to stretch a muscle or ligament so that the join involve moves freely and through its full range of motion. Sufficient flexibility is required for more effective muscular contraction, protection and maximal range of motion, which in turn is necessary for peak athletic performance.

Straight leg raise

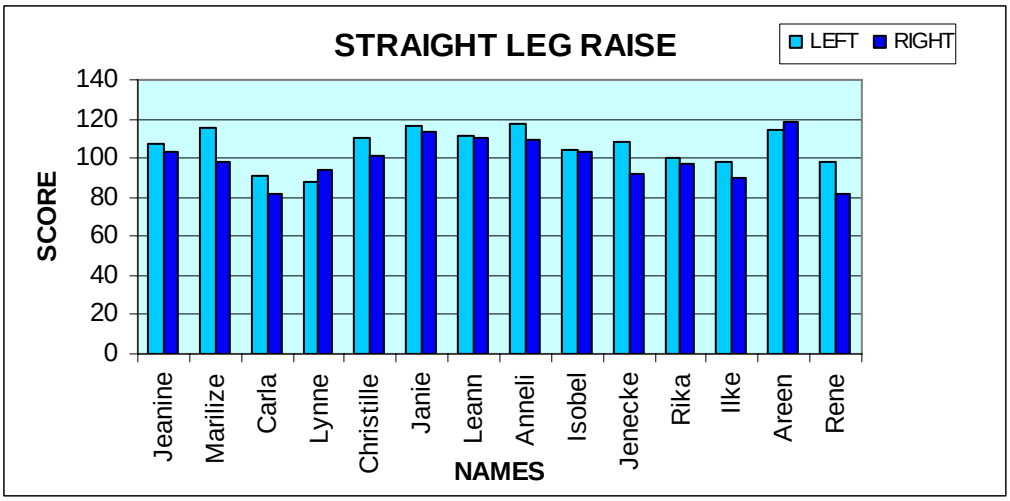
This test measures your flexibility in your hamstring muscles.

Excellent	**>100**
Average	**90-99**
Need some work	**<90**

Group averages

March 2004		June 2004	
Left	Right	Left	Right
71.3	72.1	105.6	99.5

	PRE			POST	
	LEFT	RIGHT		LEFT	RIGHT
Jeanine	70	65	**Jeanine**	107	103
Marilize	70	68	**Marilize**	115	98
Carla	70	76	**Carla**	91	82
Lynne	78	63	**Lynne**	88	94
Christille	75	77	**Christille**	110	101
Janie	45	61	**Janie**	116	113
Leann	78	62	**Leann**	111	110
Anneli	59	70	**Anneli**	118	109
Isobel	88	77	**Isobel**	104	103
Jenecke	59	75	**Jenecke**	108	92
Rika	70	76	**Rika**	100	97
Ilke	76	79	**Ilke**	98	90
Areen	71	70	**Areen**	114	119
Rene	84	83	**Rene**	98	82



Comments

Deur te kyk na die resultate van al die spelers is dit duidelik dat die lenigheideid van die hamstrings by al die spelers wel verbeter het. Dit kom tog voor of die "hurdle steps" hul werk gedoen het. Die verbetering in sommige spelers is fenominaal en dis goed om te sien dat strek oefeninge die verskil kon maak.

Modified Thomas test

This was a test measuring the flexibility of your quadriceps (front thigh) muscle group and your hip flexors (Iliopsoas) muscles. A score greater than 180º is scored as a negative value to indicate that it is bigger than 180º.

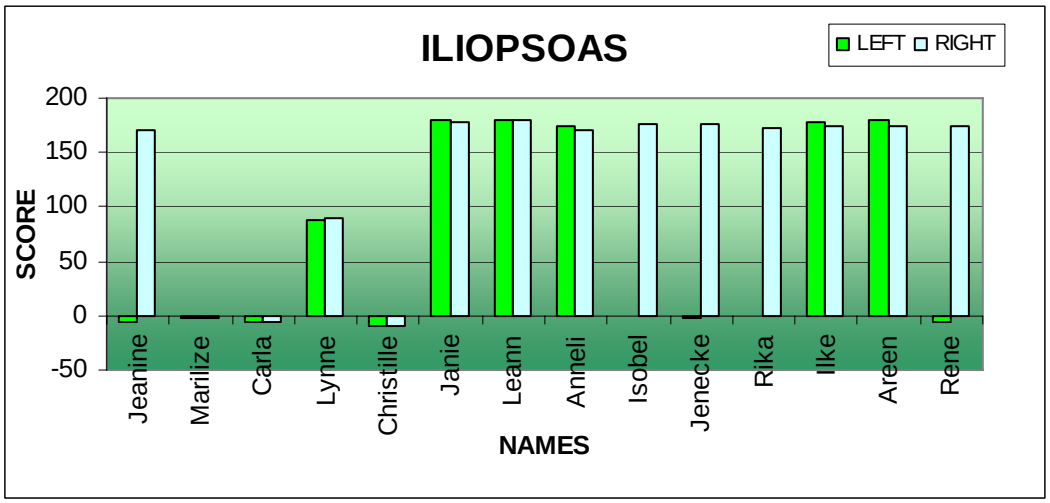
	Quadriceps	Iliopsoas
Excellent	>60	>-5
Average	50 – 60	180 – (-4)
Need some work	<50	<180

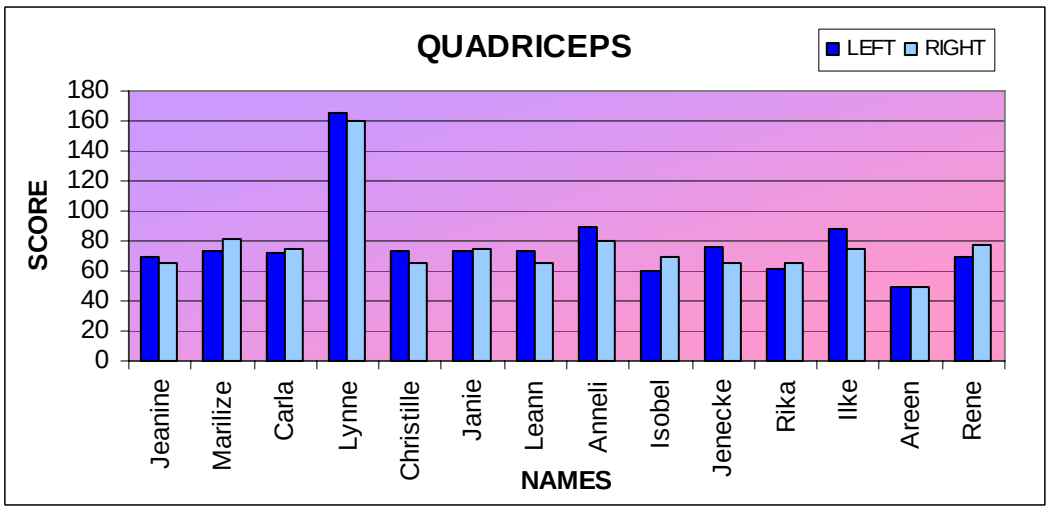
Group averages

March 2004			
Quads left	**Quads right**	**Iliopsoas left**	**Iliopsoas right**
66.6	69.3	78.3	91.6

June 2004			
Quads left	**Quads right**	**Iliopsoas left**	**Iliopsoas right**
78.3	76.4	67.8	130.1

	QUADRICEPS					ILIOPSOAS			
	PRE		POST			PRE		POST	
	LEFT	RIGHT	LEFT	RIGHT		LEFT	RIGHT	LEFT	RIGHT
Jeanine	53	64	70	66	**Jeanine**	180	168	-5	170
Marilize	62	76	74	81	**Marilize**	-9	-9	-2	-3
Carla	75	83	72	75	**Carla**	169	179	-6	-5
Lynne	70	86	165	160	**Lynne**	172	168	88	90
Christille	64	50	74	65	**Christille**	-3	179	-9	-10
Janie	72	71	73	75	**Janie**	174	179	180	178
Leann	63	62	73	65	**Leann**	-3	-3	180	180
Anneli	81	80	90	80	**Anneli**	170	172	175	170
Isobel	61	67	60	70	**Isobel**	-2	-2	-1	177
Jenecke	80	80	76	65	**Jenecke**	179	178	-3	176
Rika	51	54	61	65	**Rika**	-4	-4	-1	173
Ilke	86	76	88	75	**Ilke**	166	179	178	175
Areen	53	43	50	49	**Areen**	-1	-1	180	175
Rene	70	73	70	78	**Rene**	-12	-6	-5	175





Comments

Die ideaal vir enige netbal speler is om tussen 60–90 met quadriceps spiergroep en 0-(-10) met Iliopsoas te wees. Dit is duidelik met die resultate dat al die spelers rondom hierdie ideaal verspreid is met uitsondering sal daar aandag gegee moet word aan individue se lenigheid van die spier groepe. Vanaf die pre-toetse Maart het die balans tussen die spier groepe verbeter maar die iliopsoas spier groep is steeds te styf en elke speler sal moet ekstra strek om hierdie spiere te verleng.

Ankle mobility test

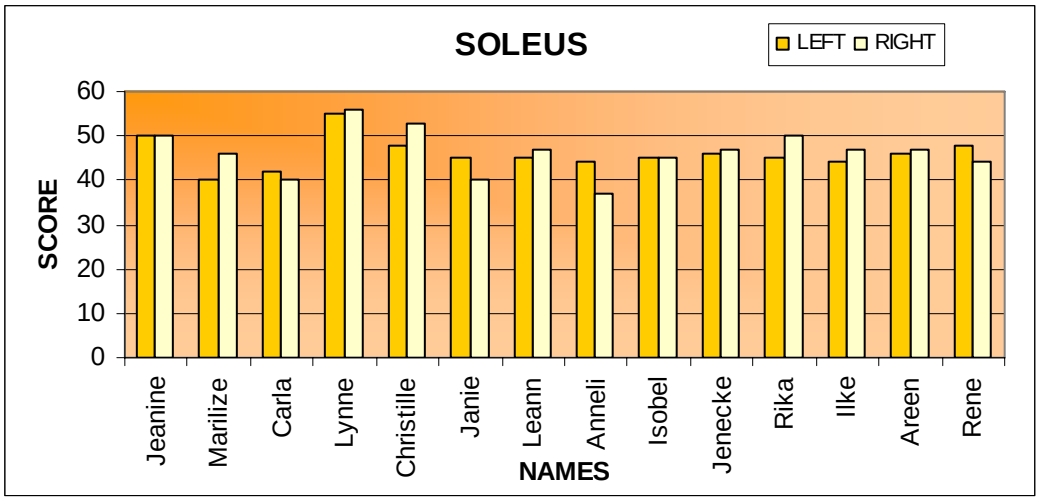
This was a test measuring the flexibility of the soleus and the gastrocnemius muscles in your calves. The score of the two ankle mobility test should fall in a 10º range.

	Soleus	Gastrocnemius
Excellent	>30º	>20º
Average	15 – 19	15 –19
Need some work	<25º	<15º

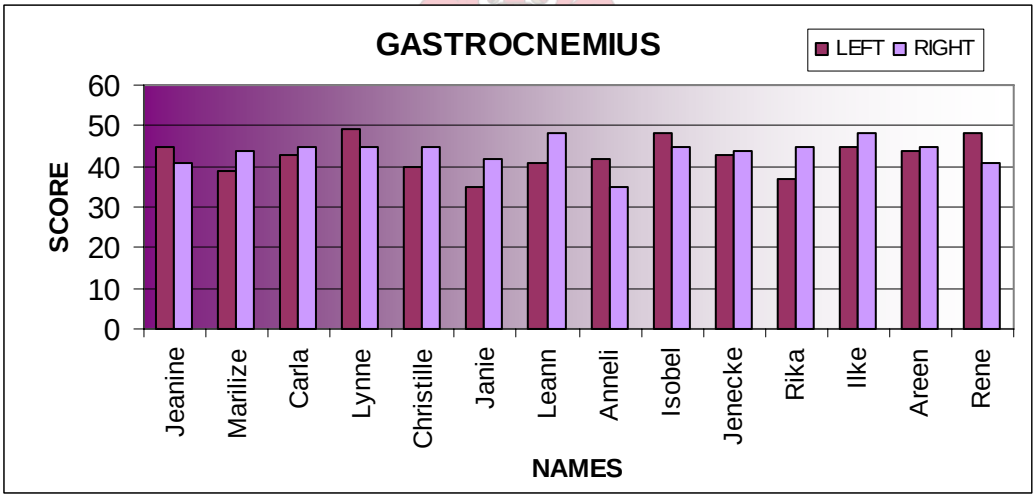
Group averages

March 2004			
Soleus left	**Soleus right**	**Gastroc left**	**Gastroc right**
47.5	45	41.8	43.1

June 2004			
Soleus left	**Soleus right**	**Gastroc left**	**Gastroc right**
45.9	46.4	42.8	43.8



	SOLEUS					GASTROC			
	PRE		POST			PRE		POST	
	LEFT	RIGHT	LEFT	RIGHT		LEFT	RIGHT	LEFT	RIGHT
Jeanine	50	49	50	50	**Jeanine**	40	45	45	41
Marilize	45	44	40	46	**Marilize**	32	39	39	44
Carla	39	41	42	40	**Carla**	33	34	43	45
Lynne	57	47	55	56	**Lynne**	45	41	49	45
Christille	50	47	48	53	**Christille**	40	46	40	45
Janie	40	46	45	40	**Janie**	40	37	35	42
Leann	52	54	45	47	**Leann**	41	45	41	48
Anneli	49	39	44	37	**Anneli**	44	66	42	35
Isobel	40	40	45	45	**Isobel**	39	39	48	45
Jenecke	48	45	46	47	**Jenecke**	42	38	43	44
Rika	53	39	45	50	**Rika**	48	52	37	45
Ilke	54	50	44	47	**Ilke**	46	39	45	48
Areen	51	44	46	47	**Areen**	40	40	44	45
Rene	45	44	48	44	**Rene**	46	44	48	41



Comments

Al die spelers se enkel buigbaarheid is baie goed. Dit is goed om te sien dat hul enkel buigbaarheid en veral hul "kuit" spiere nie verkort of te veel verleng het nie. Dit is goeie resultate.

STRENGTH

Even very small changes in muscle size can make a big difference in strength. An increase in muscle that's not even visible to the eye can be all it takes to improve your ability to do things like get up from a chair or climb stairs. Your muscles are active even if you are sleeping. Their cells are still doing the routine activities they need to do to stay alive. This work is called metabolism, and it uses up calories.

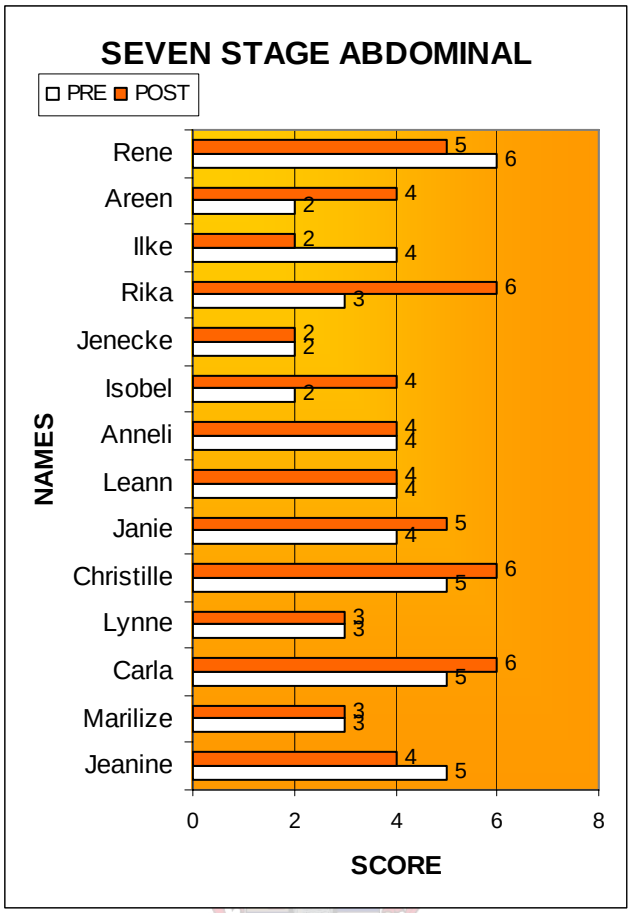
Seven stage abdominal test

To measure the strength of the abdominal muscles without using the hip flexors. It gives you an idea of how strong your core stabilizers are.

Excellent	>5
Average	4 – 5
Need some work	<4

Group averages

March 2004	June 2004
3.7	4.1



Comments

Al die spelers kan nog hul core stability verbeter. In die meerderheid het die spelers verbeter maar in uitsonderlike gevalle het spelers ‘n swakker resultaat gekry. Core stability verbeter deur die seisoen soos spelers kontak van die sport begin gewoond raak en aanpas by die veranderinge wat die liggaam met oefening ondergaan.

POWER

Power is the ability to use your strength quickly to produce an explosive action. Power is thus a function of both power and speed. It is an indication of speed potential or fast strength application from a standing or sitting position. Leg power is important for all netball players. It contribute to the speed and agility required in the action on the court. Upper body power is essential for strong passes.

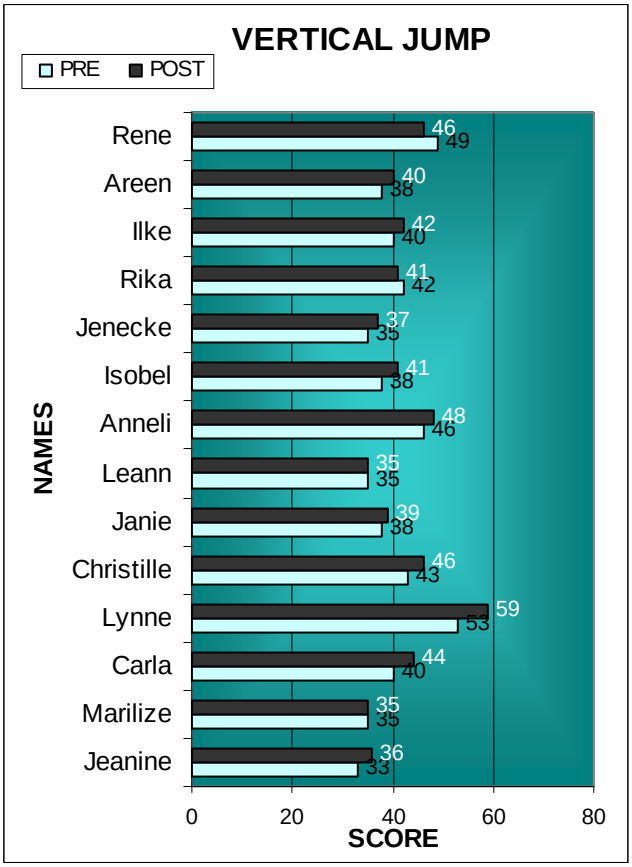
Vertical jump

The objective of testing leg power is to determine if there is sufficient power for activities such as jumping, acceleration, speed and change of direction. Although there is a certain amount of technique involved, the vertical jump is a simple field test of explosive leg power**.**

Needs a lot of work	<35
Needs work	35 – 40
Average	41 – 47
Good	48 – 54
Excellent	>55

Group averages

March 2004	June 2004
40.7	42.1



Comments

Plofkrag is een van die belangrikste kompnente van ‘n netbal speler. Die groep gemiddeld was goed en het steeds verbeter. Spelers onder 40 sal meer tyd moet aan hulle plofkrag. Dit sal ook hul spel in ‘n wedstryd verbeter as hulle meer plofkrag het om balle af te neem by die oponente ens.

MUSCLE ENDURANCE

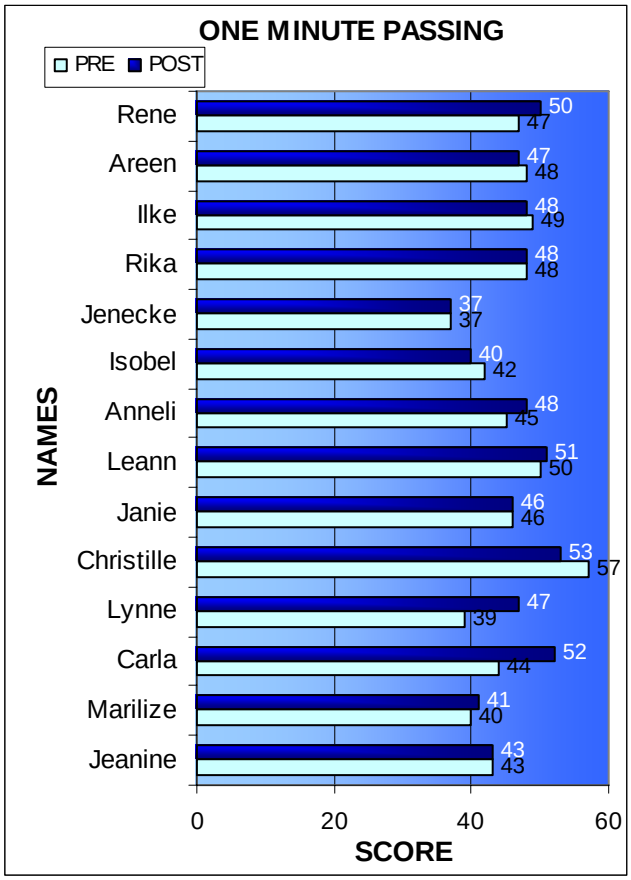
Muscle endurance is the ability to work a muscle for long periods of time at less than your maximum effort. Better muscle endurance in a specific area, will result in a player being able to maintain their level of play for longer periods.

One minute passing

The objective of testing arm strength and muscle endurance is to determine if there is sufficient power for activities such as throwing and catching. Although there is a certain amount of technique involved, the one minute passing is a simple field test of arm strength and muscle endurance.

Group averages

March 2004	June 2004
45.4	46.5



Comments

Daar is nie werklik norme vir hierdie toets nie. Die gemiddeld was redelik goed met die pre-tests en as groep het die gemiddelde wel verhoog. Oor dei algemeen het te veel spelers swakker gedoen in die post-tests. In vergelyking met ander spanne kan dit verbeter dat almal tussen 45 - 50 het aan die einde van die seisoen. Ek weet dat julle nie meer “chest passes” in die wedstryde gebruik nie maar die hele gedagte van uithouvermoë van die arms is veronderstel om hier deur te kom saam met die plofkrag van die bo-lyf.

SPEED

Speed is the ability to perform fast motor actions in a short period of time. It is the ability to move quickly. In netball, the players must accelerate over short distances in the in the court. Testing speed over these distances is relevant to netball because it simulates the varying possibilities during match play.

Maximum running speed and acceleration

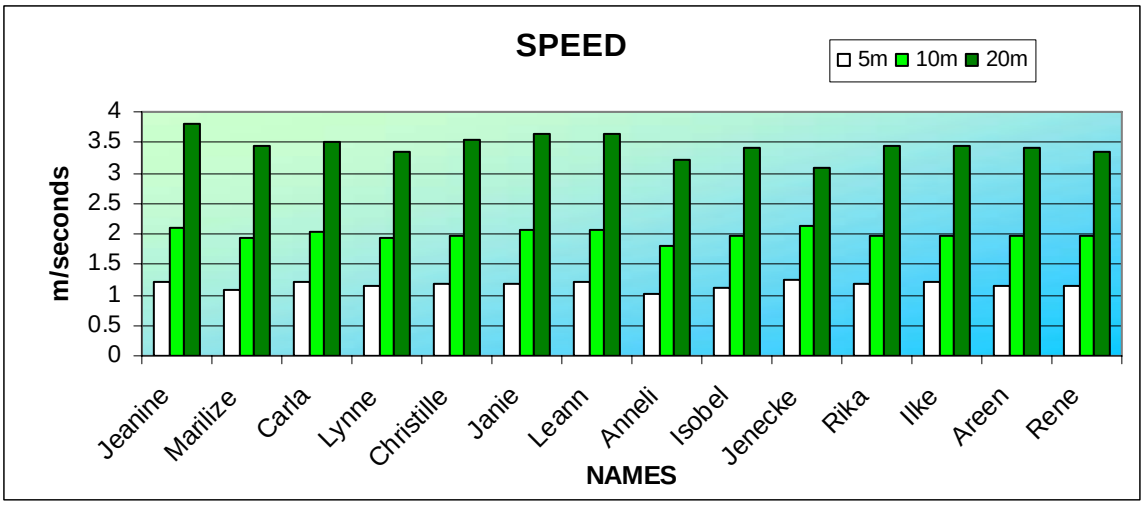
Speed can be defined as the combination of *reaction time* (time from stimulus to the start of the movement) and *movement time* (time to complete the movement). In this test speed was assessed as the body's ability to move at a high tempo with maximum efficiency over a short distance of 20 metres.

	0-5m	0-10m	0-20m
Needs a lot of work	>1.37	>2.20	>3.7
Needs work	1.36 - 1.20	2.05 - 2.19	3.5 - 3.69
Average	1.19 – 1.10	1.9 – 2.14	3.35 – 3.49
Good	1.01 – 1.10	1.75 – 1.89	3.25 – 3.34
Excellent	<1.00	<1.74	<3.25

Group averages

March 2004			June 2004		
0-5m	**0-10m**	**0-20m**	**0-5m**	**0-10m**	**0-20m**
1.19	2.03	3.49	1.17	1.98	3.44

	PRE				POST		
	5m	**10m**	**20m**		**5m**	**10m**	**20m**
Jeanine	1.21	2.17	3.89	**Jeanine**	1.22	2.09	3.79
Marilize	1.24	2.05	3.59	**Marilize**	1.09	1.92	3.43
Carla	1.13	1.94	3.46	**Carla**	1.2	2.04	3.52
Lynne	1.06	1.83	3.25	**Lynne**	1.14	1.95	3.33
Christille	1.18	2.06	2.75	**Christille**	1.19	1.96	3.53
Janie	1.16	2.01	3.65	**Janie**	1.18	2.08	3.63
Leann	1.3	2.16	3.8	**Leann**	1.21	2.05	3.65
Anneli	1.13	1.85	3.25	**Anneli**	1.03	1.8	3.2
Isobel	1.27	2.15	3.61	**Isobel**	1.13	1.96	3.41
Jenecke	1.17	2.04	3.56	**Jenecke**	1.24	2.12	3.08
Rika	1.34	2.17	3.68	**Rika**	1.18	1.97	3.44
Ilke	1.1	1.88	3.28	**Ilke**	1.2	1.98	3.43
Areen	1.19	2	3.48	**Areen**	1.16	1.96	3.42
Rene	1.17	1.95	3.33	**Rene**	1.16	1.96	3.36



Comments

Spoed is een van daardie dinge wat almal haat maar tog speel dit ‘n groot rol in sport veral netbal en soortgelyke sporte. Tydens al drie afstande val die groep steeds in die gemiddelde vlak. Die hele groep se spoed oor die algemeen het verbeter en dit is baie goed. Almal kan nou soos jy daar sit waar jy die kommentaar lees jouself op die skouer klop en sê daardie verdomde “sprints” van Lindie het gewerk.

AGILITY

Agility is the ability to change position and direction rapidly, with precision and without loss of balance. It depends on strength, speed, balance, co-ordination and neurological processing of what is happening on the field. Agility is undeniably important in the world of sport. Extreme strength isn’t a prerequisite for agility, nor is aerobic fitness; however, since agility deteriorates with fatigue, aerobic and muscular fitness should help to maintain agility for extended periods on the court.

Netball Agility Test

The objective of this test are to measure the ability of the players to change direction on both feet and sprint in a different direction.

Needs a lot of work	>2.80
Needs work	2.56 – 2.80
Average	2.45 – 2.55
Good	2.36 – 2.46
Excellent	<2.35

Group averages

March 2004		June 2004	
Left	**Right**	**Left**	**Right**
2.67	2.68	2.64	2.64

	PRE			POST	
	LEFT	**RIGHT**		**LEFT**	**RIGHT**
Jeanine	2.95	2.93	**Jeanine**	3.04	2.96
Marilize	2.71	2.83	**Marilize**	2.63	2.67
Carla	2.74	2.67	**Carla**	2.7	2.69
Lynne	2.47	2.57	**Lynne**	2.63	2.63
Christille	2.69	2.75	**Christille**	2.62	2.66
Janie	2.73	2.74	**Janie**	2.77	2.77
Leann	2.66	2.69	**Leann**	2.66	2.7
Anneli	2.67	2.56	**Anneli**	2.59	2.56
Isobel	2.6	2.62	**Isobel**	2.51	2.52
Jenecke	2.67	2.76	**Jenecke**	2.72	2.74
Rika	2.65	2.64	**Rika**	2.56	2.6
Ilke	2.58	2.68	**Ilke**	2.53	2.55
Areen	2.57	2.53	**Areen**	2.58	2.52
Rene	2.5	2.47	**Rene**	2.42	2.45

Comments

Dieselfde as met die spoed het die ratsheid van die spelers verbeter en val steeds in die vlak waar werk nog nodig is maar dis klaar ‘n verbetering. Ook iets waaroor julle klomp maar kan breebors rond loop.

ANAEROBIC FITNESS

Anaerobic fitness is the capacity to perform tasks involving the whole body for short periods of time, where the energy is produced anaerobic (with oxygen). This requires heart/lung efficiency in delivering oxygen to the working muscles. Good anaerobic capacity enhances performances of netball players.

Repeated sprint ability

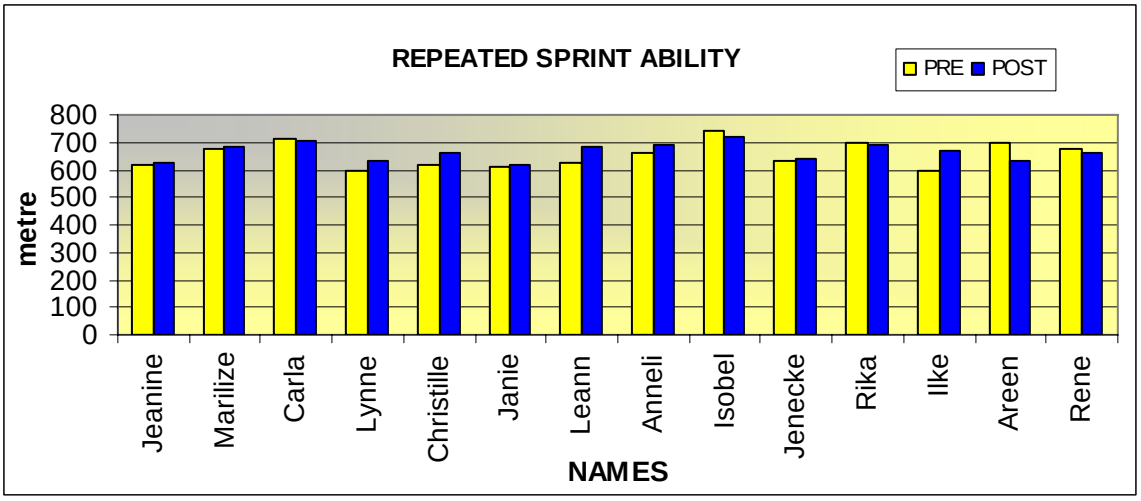
The goal of this test are to push yourself as hard as you can for 6 intervals and to go as far as possible in the 30sec.

Excellent	720 – 760 m
Good	690 – 719 m
Above average	670 – 689 m
Average	640 – 669 m
Below average	600 – 639 m
Poor	550 – 599 m

Group averages

March 2004	June 2004
655.3	665.9

	PRE	POST
Jeanine	615	627.5
Marilize	675	685
Carla	715	707.5
Lynne	600	630
Christille	620	658.75
Janie	610	620
Leann	625	682.5
Anneli	665	692.5
Isobel	740	722.5
Jenecke	635	637.5
Rika	695	692.5
Ilke	600	672.5
Areen	695	635
Rene	675	660



Comments

Hierdie toets in nou ongelukkig een van daardie goed wat jou hart laat vinniger klop en laat vra hoekom het ek ooit ja gesê vir die studie. Ek wil elkeen bedank almal het ongelooflik goed gehardloop in die toets en die feit dat julle soveel beter gedoen het is fantasties. Die groep gemiddelde het met meer as 10m opgeskuif in gemiddeld en dis baie goed. Dankie!. Weereens sal verbetering gedurende die seisoen ideal wees.

AEROBIC FITNESS

Aerobic fitness is the capacity to perform tasks involving the whole body for extended periods of time, where the energy is produced aerobically (with oxygen). This requires heart/lung efficiency in delivering oxygen to the working muscles. Good aerobic capacity enhances performances of netball players.

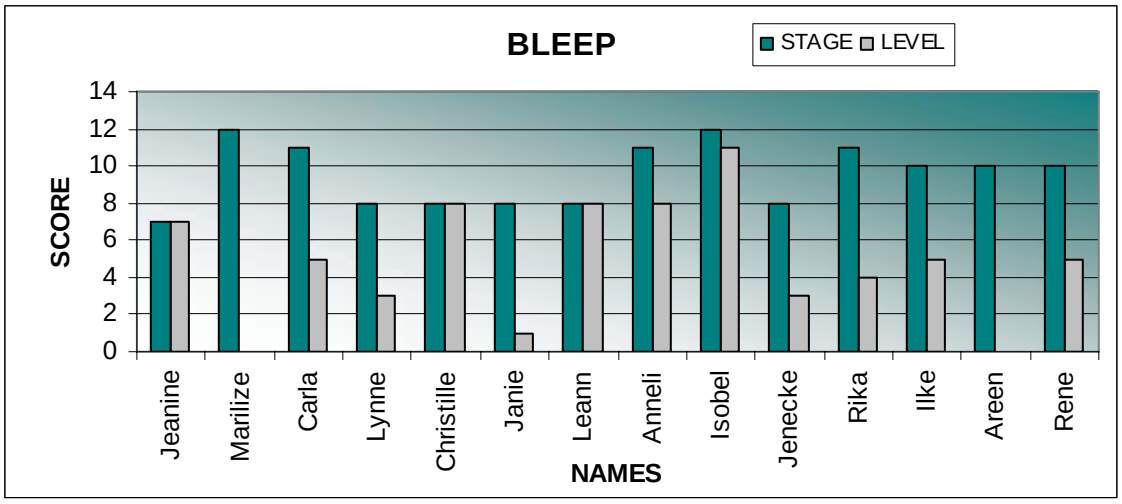
Multi stage fitness test (Bleep)

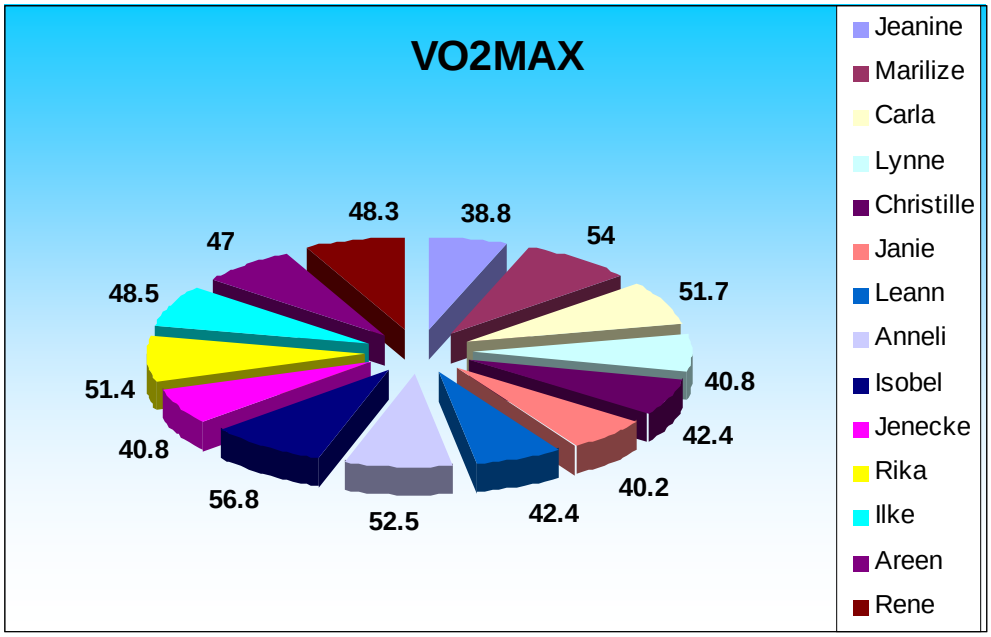
Needs a lot of work	<33
Needs work	33 – 39
Average	40 - 46
Good	47 – 54
Excellent	>55

Group averages

March 2004			**June 2004**		
Stage	**Shuttle**	**Estimated VO_2max**	**Stage**	**Shuttle**	**Estimated VO_2max**
8.1	6.1	42.3	9.6	5.7	46.8

	PRE		POST			VO2max	
	STAGE	LEVEL	STAGE	LEVEL		PRE	POST
Jeanine	6	3	7	7	**Jeanine**	34	38.8
Marilize	10	11	12	0	**Marilize**	50.2	54
Carla	10	10	11	5	**Carla**	49.8	51.7
Lynne	6	9	8	3	**Lynne**	36	40.8
Christille	6	8	8	8	**Christille**	35.7	42.4
Janie	7	4	8	1	**Janie**	37.8	40.2
Leann	7	8	8	8	**Leann**	38.8	42.4
Anneli	10	5	11	8	**Anneli**	48.3	52.5
Isobel	12	4	12	11	**Isobel**	54.8	56.8
Jenecke	6	7	8	3	**Jenecke**	35.3	40.8
Rika	10	3	11	4	**Rika**	47.8	51.4
Ilke	8	11	10	5	**Ilke**	43.3	48.5
Areen	9	2	10	0	**Areen**	43.9	47
Rene	8	1	10	5	**Rene**	40.2	48.3





Comments

Vir enige netbal speler is ‘n VO2max waarde van meer as 45 aanvaarbaar bo 50 is goed en natuurlik 60 uitstekend. Die hele Maties groep se gemiddelde het gestyg na bo 45 wat uitstekend is. Dit beteken dat julle as groep fikser is as met die pre-tests. Ek is baie trots op die resultate ek hoop julle is ook!!! Bly nou net so fiks gedurende die vakansie.

Appendix E

RAW DATA OF SUBJECTS

Experimental group (Pre test results)

Player	STRAIGHT LEG RAISE		MODIFIED THOMAS			
	Left	Right	Quads left	Quads right	Iliopsoas left	Iliopsoas right
1	70	65	53	64	180	168
2	70	68	62	76	189	189
3	70	76	75	83	169	179
4	78	63	70	86	172	168
5	75	77	64	50	183	179
6	45	61	72	71	174	179
7	78	62	63	62	183	183
8	59	70	81	80	170	172
9	88	77	61	67	182	182
10	59	75	80	80	179	178
11	70	76	51	54	184	184
12	76	79	86	76	166	179
13	71	70	53	43	181	181
14	84	83	70	73	162	186
Average	**70.928571**	**71.571429**	**67.214286**	**68.92857143**	**176.7142857**	**179.0714286**
Min	**45**	**61**	**51**	**43**	**162**	**168**
Max	**88**	**83**	**86**	**86**	**189**	**189**

Player	ANKLE MOBILITY				ONE MINUTE PASSING	VERTICAL JUMP
	Soleus left	Soleus right	Gastroc left	Gastroc right		
1	50	49	40	45	43	33
2	45	44	32	39	40	35
3	39	41	33	34	44	40
4	57	47	45	41	39	53
5	50	47	40	46	57	43
6	40	46	40	37	46	38
7	52	54	41	45	50	35
8	49	39	44	66	45	46
9	40	40	39	39	42	38
10	48	45	42	38	37	35
11	53	39	48	52	48	42
12	54	50	46	39	49	40
13	51	44	40	40	48	38
14	45	44	46	44	47	49
Average	**48.071429**	**44.928571**	**41.142857**	**43.21428571**	**45.35714286**	**40.35714286**
Min	**39**	**39**	**32**	**34**	**37**	**33**
Max	**57**	**54**	**48**	**66**	**57**	**53**

Player	7 STAGE	SPEED			AGILITY	
		5m	10m	20m	Left	Right
1	5	1.21	2.17	3.89	2.95	2.93
2	3	1.24	2.05	3.59	2.71	2.83
3	5	1.13	1.94	3.46	2.74	2.67
4	3	1.06	1.83	3.25	2.47	2.57
5	5	1.18	2.06	2.75	2.69	2.75
6	4	1.16	2.01	3.65	2.73	2.74
7	4	1.3	2.16	3.8	2.66	2.69
8	4	1.13	1.85	3.25	2.67	2.56
9	2	1.27	2.15	3.61	2.6	2.62
10	2	1.17	2.04	3.56	2.67	2.76
11	3	1.34	2.17	3.68	2.65	2.64
12	4	1.1	1.88	3.28	2.58	2.68
13	2	1.19	2	3.48	2.57	2.53
14	6	1.17	1.95	3.33	2.5	2.47
Average	**3.7142857**	**1.1892857**	**2.0185714**	**3.47**	**2.656428571**	**2.674285714**
Min	**2**	**1.06**	**1.83**	**2.75**	**2.47**	**2.47**
Max	**6**	**1.34**	**2.17**	**3.89**	**2.95**	**2.93**

Player	REPEATED SPRINT	BLEEP		
	m	Stage	Level	Estimated VO_2max
1	615	6	3	34
2	675	10	11	50.2
3	715	10	10	49.8
4	600	6	9	36
5	620	6	8	35.7
6	610	7	4	37.8
7	625	7	8	38.8
8	665	10	5	48.3
9	740	12	4	54.8
10	635	6	7	35.3
11	695	10	3	47.8
12	600	8	11	43.3
13	695	9	2	43.9
14	675	8	1	40.2
Average	**654.64286**	**8.2142857**	**6.1428571**	**42.56428571**
Min	**600**	**6**	**1**	**34**
Max	**740**	**12**	**11**	**54.8**

Experimental group (Post-tests results)

	STRAIGHT LEG RAISE		MODIFIED THOMAS			
Player	Left	Right	Quads left	Quads right	Iliopsoas left	Iliopsoas right
1	107	103	70	66	185	170
2	98	82	74	81	182	183
3	115	98	72	75	186	185
4	91	82	88	90	165	160
5	88	94	74	65	189	190
6	110	101	73	75	180	178
7	116	113	73	65	180	180
8	111	110	90	80	175	170
9	118	109	60	70	181	177
10	104	103	76	65	183	176
11	108	92	61	65	181	173
12	100	97	88	75	178	175
13	98	90	50	49	180	175
14	114	119	70	78	185	175
Average	**105.571429**	**99.5**	**72.78571**	**71.3571429**	**180.7142857**	**176.2142857**
Min	**88**	**82**	**50**	**49**	**165**	**160**
Max	**118**	**119**	**90**	**90**	**189**	**190**

	ANKLE MOBILITY				ONE MINUTE PASSING	VERTICAL JUMP
Player	Soleus left	Soleus right	Gastroc left	Gastroc right		
1	50	50	45	41	43	36
2	48	44	48	41	50	46
3	40	46	39	44	41	35
4	42	40	43	45	52	44
5	55	56	49	45	47	59
6	48	53	40	45	53	46
7	45	40	35	42	46	39
8	45	47	41	48	51	35
9	44	37	42	35	48	48
10	45	45	48	45	40	41
11	46	47	43	44	37	37
12	45	50	37	45	48	41
13	44	47	45	48	48	42
14	46	47	44	45	47	40
Average	**45.9285714**	**46.35714**	**42.78571**	**43.7857143**	**46.5**	**42.07142857**
Min	**40**	**37**	**35**	**35**	**37**	**35**
Max	**55**	**56**	**49**	**48**	**53**	**59**

Player	7 STAGE	SPEED			AGILITY	
		5m	10m	20m	Left	Right
1	4	1.22	2.09	3.79	3.04	2.96
2	5	1.16	1.96	3.36	2.42	2.45
3	3	1.09	1.92	3.43	2.63	2.67
4	6	1.2	2.04	3.52	2.7	2.69
5	3	1.14	1.95	3.33	2.63	2.63
6	6	1.19	1.96	3.53	2.62	2.66
7	5	1.18	2.08	3.63	2.77	2.77
8	4	1.21	2.05	3.65	2.66	2.7
9	4	1.03	1.8	3.2	2.59	2.56
10	4	1.13	1.96	3.41	2.51	2.52
11	2	1.24	2.12	3.08	2.72	2.74
12	6	1.18	1.97	3.44	2.56	2.6
13	2	1.2	1.98	3.43	2.53	2.55
14	4	1.16	1.96	3.42	2.58	2.52
Average	**4.14285714**	**1.166429**	**1.988571**	**3.44428571**	**2.64**	**2.644285714**
Min	**2**	**1.03**	**1.8**	**3.08**	**2.42**	**2.45**
Max	**6**	**1.24**	**2.12**	**3.79**	**3.04**	**2.96**

Player	REPEATED SPRINT ABILITY m	BLEEP		
		Stage	Level	Estimated VO_2max
1	627.5	7	7	38.8
2	660	10	5	48.3
3	685	12		54
4	707.5	11	5	51.7
5	630	8	3	40.8
6	658.75	8	8	42.4
7	620	8	1	40.2
8	682.5	8	8	42.4
9	692.5	11	8	52.5
10	722.5	12	11	56.8
11	637.5	8	3	40.8
12	692.5	11	4	51.4
13	672.5	10	5	48.5
14	635	10		47
Average	**665.982143**	**9.571429**	**5.666667**	**46.8285714**
Min	**620**	**7**	**1**	**38.8**
Max	**722.5**	**12**	**11**	**56.8**

Control group (Pre tests results)

	STRAIGHT LEG RAISE		MODIFIED THOMAS			
Player	Left	Right	Quads left	Quads right	Iliopsoas left	Iliopsoas right
1	67	68	78	79	179	175
2	65	70	82	79	176	177
3	66	60	72	74	176	176
4	82	80	63	77	180	179
5	74	78	72	66	182	184
6	65	72	67	77	175	177
7	90	88	75	70	178	179
8	62	69	70	71	177	178
9	72	60	78	79	189	184
10	72	66	71	67	170	174
11	55	75	66	61	172	169
12	83	80	79	72	186	184
13	74	79	70	69	184	188
14	65	64	62	69	184	186
15	82	71	62	69	179	170
16	82	86	65	66	192	191
Average	**72.25**	**72.875**	**70.75**	**71.5625**	**179.9375**	**179.4375**
Min	**55**	**60**	**62**	**61**	**170**	**169**
Max	**90**	**88**	**82**	**79**	**192**	**191**

	ANKLE MOBILITY				ONE MINUTE PASSING	VERTICAL JUMP
Player	Soleus left	Soleus right	Gastroc left	Gastroc right		
1	49	49	41	39	49	30.5
2	36	30	32	36	44	28
3	44	40	40	31	41	34.5
4	49	49	41	34	39	39
5	44	45	40	39	47	29.5
6	44	42	34	36	44	35
7	54	49	48	40	43	43
8	42	36	34	28	46	31.5
9	46	45	40	38	38	42
10	47	50	36	41	50	32.5
11	54	46	45	38	48	43.5
12	50	54	38	45	51	40
13	47	46	40	44	42	28.5
14	49	45	44	40	33	31
15	48	38	42	34	29	41
16	49	44	45	48	50	35
Average	**47**	**44.25**	**40**	**38.1875**	**43.375**	**35.28125**
Min	**36**	**30**	**32**	**28**	**29**	**28**
Max	**54**	**54**	**48**	**48**	**51**	**43.5**

Player	7 STAGE	SPEED			AGILITY	
		5m	10m	20m	Left	Right
1	4	1.31	2.17	3.79	2.8	2.71
2	3	1.3	2.31	4.15	3.13	3.09
3	0	1.32	2.2	3.82	2.98	2.88
4	4	1.1	1.89	3.39	2.84	2.66
5	3	1.27	2.15	3.85	2.88	2.8
6	4	1.38	2.23	3.76	3.25	3.31
7	2	1.22	2.09	3.68	2.91	2.85
8	3	1.21	2.11	3.68	2.88	2.8
9	3	1.2	2.07	3.67	2.81	2.69
10	5	1.35	2.21	3.76	2.91	2.82
11	1	1.13	1.92	3.38	2.68	2.55
12	4	1.22	2.05	3.57	2.73	2.68
13	2	1.35	2.24	3.96	3.01	3.06
14	4	1.22	2.1	3.66	3.11	3.01
15	5	1.22	2.06	3.67	2.79	2.84
16	5	1.25	2.1	3.67	2.97	2.63
Average	**3.25**	**1.253125**	**2.11875**	**3.71625**	**2.9175**	**2.83625**
Min	**0**	**1.1**	**1.89**	**3.38**	**2.68**	**2.55**
Max	**5**	**1.38**	**2.31**	**4.15**	**3.25**	**3.31**

Player	REPEATED SPRINT	BLEEP		
	m	Stage	Level	Estimated VO_2max
1	670	8	7	41.1
2	595	5	11	33.3
3	590			
4	540			
5				
6	585			
7	622.5			
8	610	4	8	29.1
9	637.5			
10	650			
11	635			
12	665			
13	560	5	9	32.9
14	610	6	4	34.3
15	600			
16	675	8	9	43
Average	**616.3333**	**6**	**8**	**35.61666667**
Min	**540**	**4**	**4**	**29.1**
Max	**675**	**8**	**11**	**43**

Control group (Post-tests results)

	STRAIGHT LEG RAISE		MODIFIED THOMAS			
Player	Left	Right	Quads left	Quads right	Iliopsoas left	Iliopsoas right
1	75	81	77	80	183	176
2	75	70	90	92	170	165
3	90	95	75	65	182	180
4	72	73	48	52	178	178
5	81	64	72	80	180	181
6	70	58	82	78	175	175
7						
8	87	67	75	78	179	170
9	75	78	90	90	182	180
10						
11	57	69	75	82	191	178
12	120	90	64	80	182	181
13	68	91	76	81	195	189
14						
15	90	88	76	80	176	168
16						
Average	**80**	**77**	**75**	**78.16666667**	**181.0833333**	**176.75**
Min	**57**	**58**	**48**	**52**	**170**	**165**
Max	**120**	**95**	**90**	**92**	**195**	**189**

	ANKLE MOBILITY				ONE MINUTE PASSING	VERTICAL JUMP
Player	Soleus left	Soleus right	Gastroc left	Gastroc right		
1	48	51	46	49	48	33
2	40	38	35	36	50	27
3	40	38	34	34	41	31
4	48	44	36	31	41	25
5	43	44	38	42	41	35
6	46	46	36	40	45	27
7						
8	43	37	35	34	48	29
9	50	45	38	39	46	42
10						
11	43	47	40	35	52	38
12	44	38	29	35	52	31
13	46	47	38	42	30	24
14						
15	51	50	42	41	37	34
16						
Average	**45.16666667**	**43.75**	**37.25**	**38.16666667**	**44.25**	**31.33333333**
Min	**40**	**37**	**29**	**31**	**30**	**24**
Max	**51**	**51**	**46**	**49**	**52**	**42**

Player	7 STAGE	SPEED			AGILITY	
		5m	10m	20m	Left	Right
1	2	1.28	2.18	3.8	2.78	2.75
2	2	1.35	2.31	4.11	2.65	2.92
3	0	1.26	2.15	3.69	2.65	2.79
4	2	1.14	1.96	3.42	2.62	2.54
5	2	1.25	2.16	3.75	2.63	2.61
6	4	1.21	2.11	3.57	2.98	2.85
7						
8	4	1.2	2.08	3.67	2.76	2.78
9	4	1.14	2.02	3.58	2.52	2.68
10						
11	1	1.13	1.95	3.34	2.46	2.47
12	2	1.2	2.01	3.52	2.5	2.5
13	1	1.21	2.1	3.77	2.85	2.87
14						
15	4	1.17	2.01	3.49	2.63	2.62
16						
Average	**2.333333333**	**1.211666667**	**2.086666667**	**3.6425**	**2.669166667**	**2.698333333**
Min	**0**	**1.13**	**1.95**	**3.34**	**2.46**	**2.47**
Max	**4**	**1.35**	**2.31**	**4.11**	**2.98**	**2.92**

Player	REPEATED SPRINT	BLEEP		
	m	Stage	Level	Estimated VO_2max
1	632.5			
2	580	6	1	33.4
3	627.5	6	1	33.4
4	610			
5	612.5	6	1	33.4
6	610			
7				
8	627.5	5	5	31.4
9	637.5	9	3	44.2
10				
11	652.5			
12	710			
13	535	5	4	31
14		7	1	36.8
15	592.5			
16				
Average	**618.9583333**	**6.285714286**	**2.285714286**	**34.8**
Min	**535**	**5**	**1**	**31**
Max	**710**	**9**	**5**	**44.2**