PHYSIOLOGICAL CHANGES ASSOCIATED WITH LATERAL MOVEMENT TRAINING OF NETBALL PLAYERS

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DECLARATION

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

Signature Date

ABSTRACT

The purpose of this study was to investigate the influence of a six-week lateral movement training programme on selected physiological variables in netball players. Calf and thigh girth measurements, mass, body fat percentage, lateral agility, lateral flexibility, dynamic balance, heart rate and isokinetic concentric and eccentric quadriceps, hamstring, abductor and adductor muscle strength, were measured. A pre-recorded, six-week slide board training programme was followed in order to: increase calf and thigh girth measurements, decrease mass, decrease body fat percentage, increase lateral agility, increase lateral flexibility, better dynamic balance, meet the prescribed guidelines in terms of heart rate and increase the isokinetic muscle strength.

The subjects (n=23) were between the ages of 18-23 years. They either played netball for the 1st or 2nd netball teams of the Maties Netball Club, or for the 1st or 2nd netball teams of the residence Nerina. They entered the study voluntarily. All of the subjects participated in the pre- and post-tests. Fourteen subjects completed the six-week lateral movement training programme.

Various significant differences ($p < 0.05$) were found between the pre- and post-test measurements: a significant decrease in body fat percentage, an increase in lateral agility, a decrease in mass, an increase in dynamic balance, an increase in concentric and eccentric abductor and adductor muscle strength, as well as an appropriate aerobic heart rate response.

It was concluded that the lateral movement training programme proved to be beneficial to netball players at any level of fitness and participation. The programme provided an excellent aerobic workout, with either improvement or maintenance of the selected variables.

Key words: lateral movement training, netball, calf and girth measurements, mass, body fat percentage, lateral agility, lateral flexibility, dynamic balance, heart rate, isokinetic muscle strength

OPSOMMING

Die doel van die studie was om ondersoek in te stel na die invloed van 'n ses-weeklange laterale bewegingsoefenprogram op geselekteerde fisiologiese veranderlikes in netbal speelsters. Kuit- en bobeenomtrekmates, massa, liggaamsvetpersentasie, laterale ratsheid, laterale lenigheid, dinamiese balans, harttempo en isokinetiese konsentriese en eksentriese quadriceps-, hampeus-, abduktor- en adduktorspierkrag, is gemeet. 'n Vooraf opgestelde, ses-weeklange laterale oefenprogram is gevolg om: die kuit- en bobeenomtrekmates te vergroot, die massa te verminder, die liggaamsvetpersentasie te verlaag, die verbetering van laterale ratsheid, laterale lenigheid en dinamiese balans te bewerkstellig, die voorgestelde riglyne in terme van harttempo te handhaaf en om isokinetiese spierkrag te vermeerder.

Die proefpersone (n=23) was tussen 18-23 jaar oud. Die proefpersone het óf vir die 1ste of 2de netbalspanne van die Maties Netbalklub gespeel, óf vir die 1ste of 2de netbal spanne van die koshuis Nerina. Hulle deelname was volkome vrywillig. Al die proefpersone het aan die pre- en post-toetse deelgeneem. Veertien proefpersone het die ses-weeklange laterale bewegingsoefenprogram voltooi.

Verskeie beduidende verskille ($p < 0.05$) tussen die pre- en post-toetse is gevind: 'n beduidende afname in liggaamsvetpersentasie, 'n toename in laterale ratsheid, 'n afname in massa, 'n toename in dinamiese balans, 'n toename in konsentriese en eksentriese abduktor- en adduktorspierkrag, asook 'n ooreenstemmende harttempo reaksie.

Daar is tot die gevolgtrekking gekom dat die laterale bewegingsoefenprogram tot voordeel strek van netbalspeelsters op enige vlak van fiksheid en deelname. Die program bied 'n goeie aërobiese komponent met óf die verbetering, óf die handhawing van die geselekteerde veranderlikes.

Sleutelwoorde: laterale bewegingsoefenprogram, netbal, kuit- en bobeenomtrekmates, massa, liggaamsvetpersentasie, laterale ratsheid, laterale lenigheid, dinamiese balans, harttempo, isokinetiese spierkrag

DEDICATION

To my mother, Stella and father, Koot

for their undenying love, support,

understanding and motivation.

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What lies behind us and
what lies before us,
are tiny matters, compared
to what lies within us.

Walt Emerson

CHAPTER ONE

INTRODUCTION

This study reflects the research done on 23 subjects, aged between 18 and 25 years, who voluntarily participated in a six-week lateral movement training or slide board training programme.

The subjects were divided into the following groups:

Group 1: healthy female netball players (N=5) from the 1st and 2nd netball teams of the Maties Netball Club of the University of Stellenbosch.

Group 2: healthy female netball players (N=9) from the 1st and 2nd netball teams of the residence Nerina.

Group 3: healthy female netball players (N=9) as the control group.

The physiological variables included:

- girth measurements of the calf and thigh regions,
- weight measurement,
- body fat percentage,
- lateral agility,
- lateral flexibility,
- dynamic balance,
- heart rate,
- isokinetic concentric and eccentric quadriceps, hamstring, abductor and adductor muscle strength.

1.1 LIMITATIONS

Certain limitations were identified during the course of the research.

- **The subjects' physical activity levels outside of the slide board training programme could not be controlled.** Especially as the netball players from the club had to participate in the normal club training sessions, which not only included the basic functional training sessions, but also fitness sessions which consisted of plyometric exercises and kick-boxing aerobics.

  A few of the subjects were also selected for regional teams, which meant that they participated in not only the club training sessions, but the regional teams' training sessions as well. These subjects were therefore training nearly twice as much compared to the other subjects.

  This inability to control the activity levels of the subjects, also made it impossible for the researcher to control the physical state of the subjects with regards to injuries. During the six-week training period, seven subjects could not continue with the slide board training sessions due to knee (2), back (1), ankle (1) and groin (1) injuries (all of these subjects, except two, were from the Maties Netball Club). The underlying reason seemed to be that the subjects were suffering from overtraining and burnout, which lead to the aggravation of old injuries. It was also found that the subjects were doing plyometric exercises on a concrete floor, instead of a spring floor, which will absorb the forces. The latter could explain the knee, back and groin injuries. One subject suffered a back injury while participating in recreational sport.

- **It was not possible for the researcher to control the eating and sleeping habits of the subjects**, which may have influenced the tests and exercise results.

- **The subjects were not always able to exercise at the same time of day, because they were students with varying class schedules.** The subjects had to exercise when they were able to fit it into their schedule. Sometimes the exercise session was in the early morning, at other times it was in the late afternoon.

- **The motivational levels of the subjects during data collection and lateral movement training session could not be controlled.**

1.2 HYPOTHESIS

Null hypothesis: improvement of selected physiological aspects in netball players by means of lateral movement training or slide board training.

The above hypothesis is subdivided into smaller hypotheses or statements to provide clarity and insight into the research programme.

1. Lateral movement training will increase thigh and calf girth measurements.

2. Lateral movement training will decrease body fat percentage.

3. Lateral movement training will lead to a decrease in body weight.

4. Lateral movement training will increase lateral agility.

5. Lateral movement training will increase lateral flexibility.

6. Lateral movement training will lead to better dynamic balance.

7. Lateral movement training will increase concentric and eccentric quadriceps, hamstring, abductor and adductor muscle strength.

8. Lateral movement training sessions will meet the ACSM guidelines for aerobic exercise in terms of heart rate, i.e. a heart rate of 60% to 90% of heart rate maximum.

CHAPTER TWO

LITERATURE STUDY

2.1 INTRODUCTION

The introduction of new forms of exercise into the commercial or consumer markets is usually viewed with scepticism in the scientific community until research and documentation regarding their validity and training effects are obtained.

Aerobic exercise, with all its benefits and various forms (low-impact, water aerobics, bench aerobics, cycle ergometers, stair climbers and aqua-joggers) has been integrated into fitness and training programmes during the past few years, because it is intrinsically safe and simple to operate (Legwold, 1982:147; Silvestri & Oescher, 1990:595). These exercise forms can also be scaled to fit individuals' changing fitness level (Harmer, 1991:32).

Recently the slide board, or lateral movement trainer as it is known in the scientific world, found wider application as a general conditioning, training and rehabilitation device. As with any new mode of training or exercise, there is concern regarding its purported training benefits (Williford, 1994:35). The aim of this chapter is therefore to provide information to those interested in the concept of lateral movement training or slide boarding and the possible application thereof in sport-specific training. This is specifically relevant due to the fact that there are very few studies on slide board training in scientific literature.

The chapter is subdivided into the following headings:

2.2 Lateral movement training or slide boarding
2.3 Lateral movement trainer or slide board
2.4 Implications of lateral movement training for athletes
2.5 Dependent variables
2.6 Netball
2.7 Conclusion

2.2 LATERAL MOVEMENT TRAINING OR SLIDE BOARDING

Lateral movement training, also referred to as slide board training, conditions the lower body musculoskeletal system and the cardiorespiratory system through side-to-side gliding motions (Stevens, 1994:29). The boards used can differ in length and participants push themselves back and forth across the length of the board in an open-legged, gliding movement (see Figure 2.1).

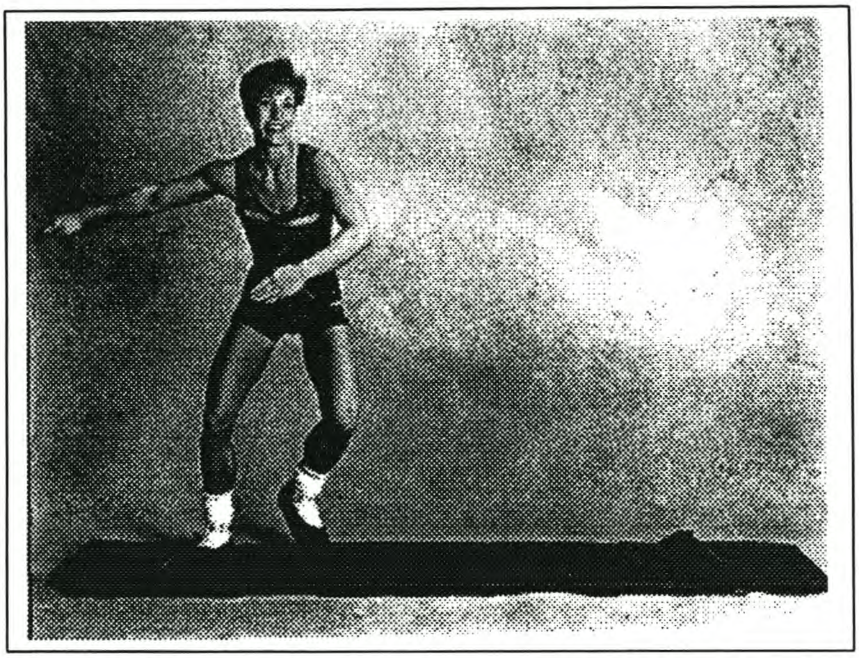


Figure 2.1: An adjustable slide board for lateral movement training (Gosselin, 1994).

2.2.1 Background and history

Slide board training has been known for more than 100 years. Originally it was utilised by Scandinavian speed skaters. Modern day speed skater Eric Heiden drew attention to the lateral movement trainer during the 1980 Olympics by claiming that the slide board was the reason for his unprecedented win of five gold medals (Stevens, 1994:30; Quinney, 1990:321). Heiden used the slide board in his off-ice training programme by simulating on it the movement pattern and physiological demands of speed skating. Speedskaters have utilised this off-ice technique to varying degrees since that time (Harmer, 1991:32).

Bergfield and Anderson (Diener, 1994:26) first described the use of the lateral movement trainer in clinical research. They found it an ideal exercise modality to achieve mobility, strength and functionality of the injured knee. Originally developed in 1984 to rehabilitate torn anterior cruciate ligaments of the knee, the lateral movement trainer has gained popularity not only as a rehabilitative device (deceleration prior to contact with the endplates causes hamstring muscles to contract, preventing the last few degrees of full extension of the knee which is most vulnerable to the anterior cruciate ligament), but as a conditioning exercise as well (Thomas, 1995:13).

Simultaneously modern athletes have discovered the benefits of slide training. Rehabilitation centres too have recognised its potential in recuperative therapy. Lateral movement training effectively stimulates muscles and attachment tissue of the lower body. Not only does the movement have very low impact on the joints, but it also provides closed chain rehabilitation, which is critical in returning a patient to multi-plane, multi-joint movements (Stevens, 1994:30).

Anderson and Montgomery (1988) state that alpine skiers possess muscular strength, co-ordination, agility, balance and flexibility and since lateral movement training was developed to train Alpine skiers and speed skaters, lateral movement training should enhance the above-mentioned factors.

2.2.2 Closed kinetic chain activities

Closed kinetic chain activities are activities that involve the integration of muscle joints acting in sequential order with combined weight bearing and shear forces that are mediated by eccentric muscle action (Malone & Sanders, 1993:180). They therefore refer to distal-end-fixed positions involving weight-bearing positions, such as the squat or the glide phase during sliding. A closed kinetic chain exercise thus exists when the foot meets resistance. The closed kinetic chain exercise is weight bearing and leads to joint compression. Theoretically it thus adds stability to the joint. The stresses placed on the limb also serve to prevent muscle and bone atrophy and to improve proprioception (Chan & Mafulli, 1996:54; Thomas, 1995:13). Clarke (1996) also states that slide board training is a closed kinetic chain exercise, which may be used as a conditioning and rehabilitative tool.

2.2.3 Planes of motion

Three primary planes of movement correlate to the present modes of conditioning. The **sagittal plane** includes movement in up or down and forward or back directions. The **frontal plane** includes side-to-side movements and the **transverse plane** includes rotational movements. Sports activities usually combine all three planes.

A problem with traditional modes of exercise in the gymnasium is that they train in the sagittal plane and do not adequately build strength in the frontal plane. Exercise rarely progresses to the frontal plane against a resistance, which will elicit a training response (Gosselin, 1994:13). Usually there is therefore inappropriate preparation for the sudden, lateral movements that are part of most recreational sports, from tennis to netball. High-speed film studies show lateral strength plays an important role in stabilising the forward movements, even in sports such as jogging and bowling (Stevens, 1994:30; Ross, 1996:100).

It is not surprising that Rover (1997:76) states that the medial and lateral thighs (hip abductors and adductors) stabilise the legs and hips, which is vital for any kind of locomotion, including walking and running.

The lateral movement trainer thus fulfils the need that exists for exercise in the frontal plane, which then flows through to the other areas of movement.

2.2.4 Functional training

An athlete's skill is the product of strength, flexibility, agility and cardiovascular endurance (Reese & Lavery, 1991:22). The ability to make the transition from the weight-room or training-room to the field of competition is the goal in preparing athletes for an event.

As training practices have evolved, functional activities have become a significant part of all conditioning programmes. Functional training may involve activities that are directly associated with the skill used in competition. There also are indirectly associated activities that develop the same physiological or neurological components of the sport skill, but are not the specific motor patterns of the skill. It is also important to realise that functional activity may be directly associated with one sport, whilst being indirectly associated with another.

Athletes and coaches continue to invent and investigate new training programmes to improve performance. Proponents claim that slide boarding enhances proprioception, balance, co-ordination and agility (particularly lateral agility) (Harmer, 1991:32; Neporent, 1993:54) as a result of the functional, three-dimensional movement pattern used in slide board training.

Although the relationship between slide board motion and sports such as skating, Alpine skiing and cross-country skiing is apparent, the ability to move laterally quickly is important in activities involving cutting and planting, such as racquet sports, soccer, basketball, rugby, hockey and netball. Slide boards are reported to be the only training device currently available that is able to develop this ability in the gymnasium.

2.3 LATERAL MOVEMENT TRAINER OR SLIDE BOARD

The lateral movement trainer is a rectangular board, constructed from different materials, such as Formica, Plexiglas or composites such as high-density polymers. It may also be constructed from a composition of diverse materials. It measures about two feet wide (61 cm) by five to 12 feet long (1.5m to 3.6m), with a padded endplate at each end (see Figure 2.2).

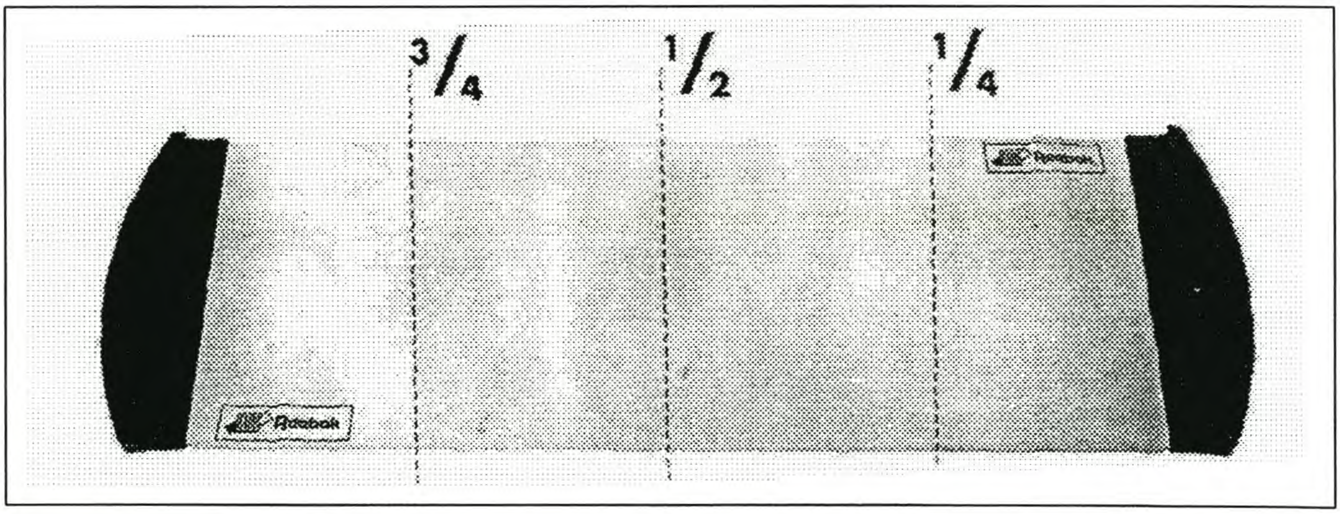


Figure 2.2: The slide board (Gosselin, 1994).

The best brands are rigid and have adjustable endplates to provide different sliding distances. The vinyl slides that can be rolled up to save space are becoming more popular. Nylon slide socks worn over sport shoes are required footwear. The only other maintenance needed is polish to keep the board slick (Diener, 1994:26).

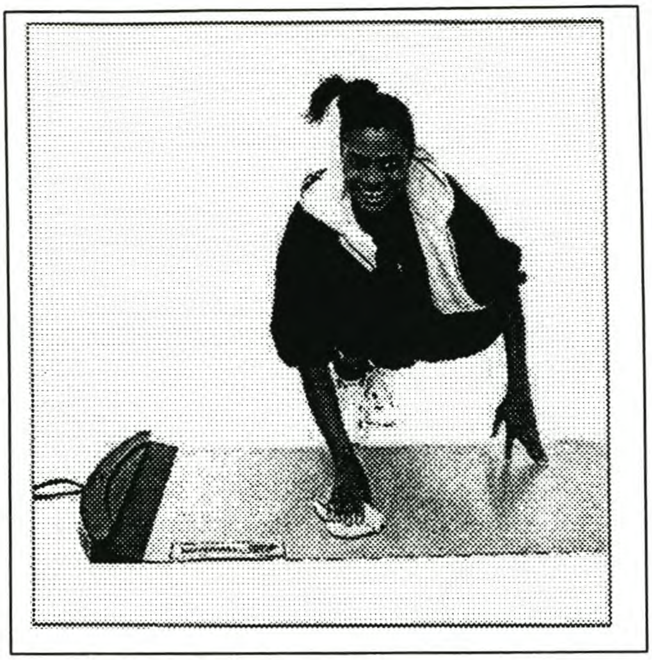


Figure 2.3: Polish the board regularly to keep it in good condition (Gosselin, 1994).

Some slide boards have their endplates angled to accommodate the form of the foot during the slide motion and to facilitate an effective push-off phase. It was found that the optimal angle for efficient application of force on a slide board endplate is approximately 40° (Utsumi, 1995:9).

2.3.1 Biomechanics of sliding

The exercise begins with the feet together against one of the endplates. The hips are flexed with the upper body at a slight forward angle. The knees should be slightly flexed, 50° to 80° are the most common recommendation (Reese & Lavery, 1991:22; Williford, 1994:35; Clarke, 1996:34).

The sliding motion consists of three phases – the push-off phase, the glide phase and the contact-recovery phase. During the push-off phase the outside leg applies force against the endplate utilising hip abduction and hip and knee extension, which initiates the movement (see Figure 2.4). The following glide phase, during which the legs remain in a wide stance, the lower-body muscles stabilise the movement by remaining isometrically contracted. Drag applied by the trailing leg can create a higher intensity, as well as an eccentric contraction of the hamstring and adductor muscles (see Figure 2.4).

In the final contact-recovery phase, the leading leg makes contact with the endplate, slows the movement and stabilises the body for the next glide. With the completion of the movement (see

Figure 2.4) this phase engages the hip and knee extensors and hip abductors of the leading leg (which makes contact with the endplate) and the adductors of the trailing leg.

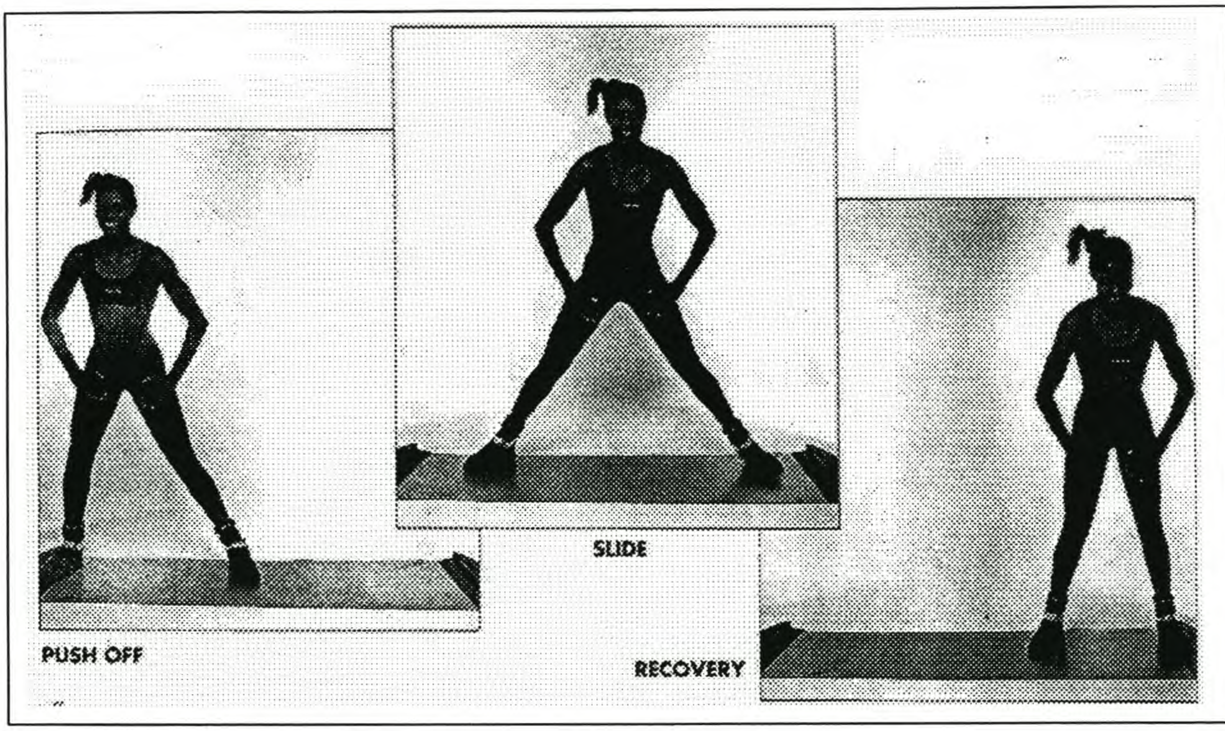


Figure 2.4: The push-off, slide and recovery phases of slide (Gosselin, 1994).

Slide movements can be performed in an *upright stance,* or in the higher intensity *athletic ready stance*. For lower back support the hands must be kept on the thighs during the *athletic ready stance*. Participants with weak lower back muscles should remain in the *upright stance* until they have built up more strength (Stevens, 1994:30).

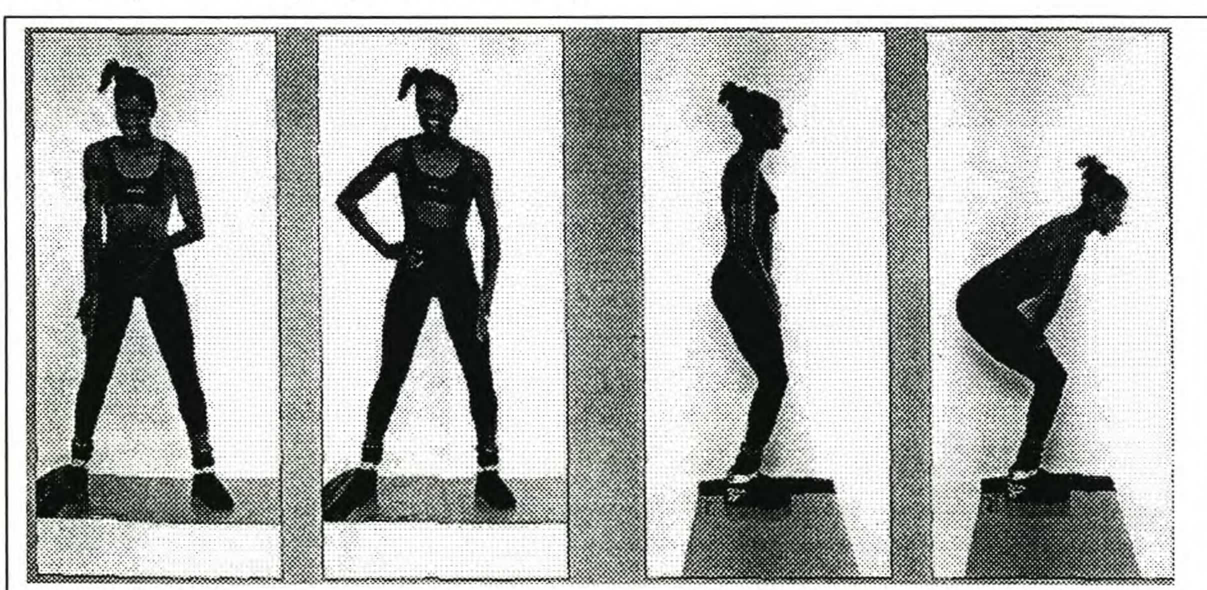


Figure 2.5: The upright and athletic stances (Gosselin, 1994).

2.3.2 Motion safety procedures

Stevens (1994:30-31) recommends the following:

<u>During the push-off phase:</u>

- Use leg flexion and extension to help apply force and assist the leg abduction.
- Keep knee torque minimal.
- Place one foot on a non-slip surface for a secure first push-off.

<u>During the glide phase:</u>

- Maintain a wide stance of at least shoulder width.
- Try to keep a constant coefficient of friction throughout the slide.
- Ensure the slide has a smoothe flat surface.
- Make sure the slide socks provide enough friction to elicit a workload on the cardiovascular system, but not so much that it would impede the smooth motion.

<u>During the contact-recovery phase:</u>

- Practise decelerating safely and stopping the body before changing direction.
- Help absorb shock with leg flexion, which also assists in deceleration and leg adduction.
- Keep the knee torque minimal.

These recommendations are dependent upon the construction of the slide board being biomechanically efficient. For example, angled endplates or ramps are preferable.

2.3.3 Lateral movement training techniques

Slide boarders commonly use two techniques. The first is a 'big-slide' movement in which an individual pushes off strongly from one end of the slide board and tries to slide as far as possible across the board. By applying this technique accomplished slide boarders move quickly from one end of the board to the other. This 'big-slide' motion often simulates speed skating, with the foot of the leading leg sliding along the surface of the slide board while the foot of the trailing leg is held behind the body, the leg being flexed at the knee.

The second technique is an 'abduction-adduction' pattern in which the feet are alternately abducted and adducted. With this technique a slide boarder gradually works his or her way back and forth without the long, powerful slides associated with the first technique.

The advantage of the second technique is that the feet are always in contact with the slide board surface, with the leg muscles working almost constantly. The disadvantage is that the high-power movements of 'big-sliding' are not utilised. Research however, suggest that changing the slide board technique will not have substantial impact on heart rate, ventilation, oxygen consumption, fat oxidation, or perceived effort during a slide board session (Anderson, 1993:4; Clarke, 1996:39).

2.3.4 Muscles involved in lateral movement training

The lateral movement trainer uses bodyweight and the inertia it generates, as resistance. Although the movement requires concentric (the muscles shorten) extension of the hip and knee for the push-off phase, it also uses the posture muscles in a static (isometric) contraction during the sliding phase. The posture muscles for the upright position include, for example, the gluteus maximus, minimus and medius, as well as the tensor fascia latae, psoas minor and major (Luttgens, Deutsch & Hamilton, 1992:468).

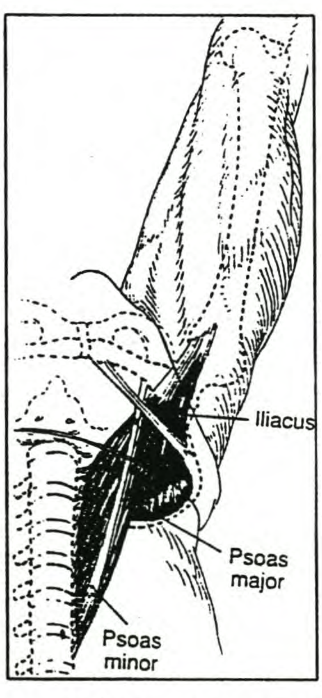


Figure 2.6: The psoas major and psoas minor posture muscles (Kendall, *et al.*, 1993).

In order to overcome the inertia, the slide uses the hamstring muscles (semimembranosus, semitendinosus and biceps femoris) in an eccentric (the muscle lengthens) contraction throughout the slide. As in skating, the push-off motion requires the use of the whole hip extensor muscle group (gluteus medius and minimus), and the whole knee extensor muscle group (sartorius, rectus femoris, tensor fasciae latae and tractus illiotibialis) (Basmajian, 1978:244). The gastrocnemius and soleus (calf muscles) also work (Diener, 1994:27).

Ankle extensors (plantar flexors), for example the gastrocnemius and the soleus, contract during the push-off phase. During the slide phase the muscles remain tight to overcome the inertia generated. The hamstring muscles, which remain in a static (isometric) contraction throughout the slide and assist in slowing the body down during the braking phase when reaching the endplate, work hard.

The bent forward position required to maintain balance, means that posture muscles are also involved. These are mainly the back extensors (a series of muscles that keep the spine upright), abdominals (rectus abdominus) and internal and external oblique muscles that wrap around the lateral sides of the body and keep the body from swaying sideways when reaching the endplates.

Klein and Hall (1963:5) and Helal, King and Grange (1986:368) also emphasise the fact that thigh muscles have an important role to play as a support system for the knee. Conditioning of the thigh muscles (abductors and adductors) will lead to better stability of the knee, minimising the possibility of injury.

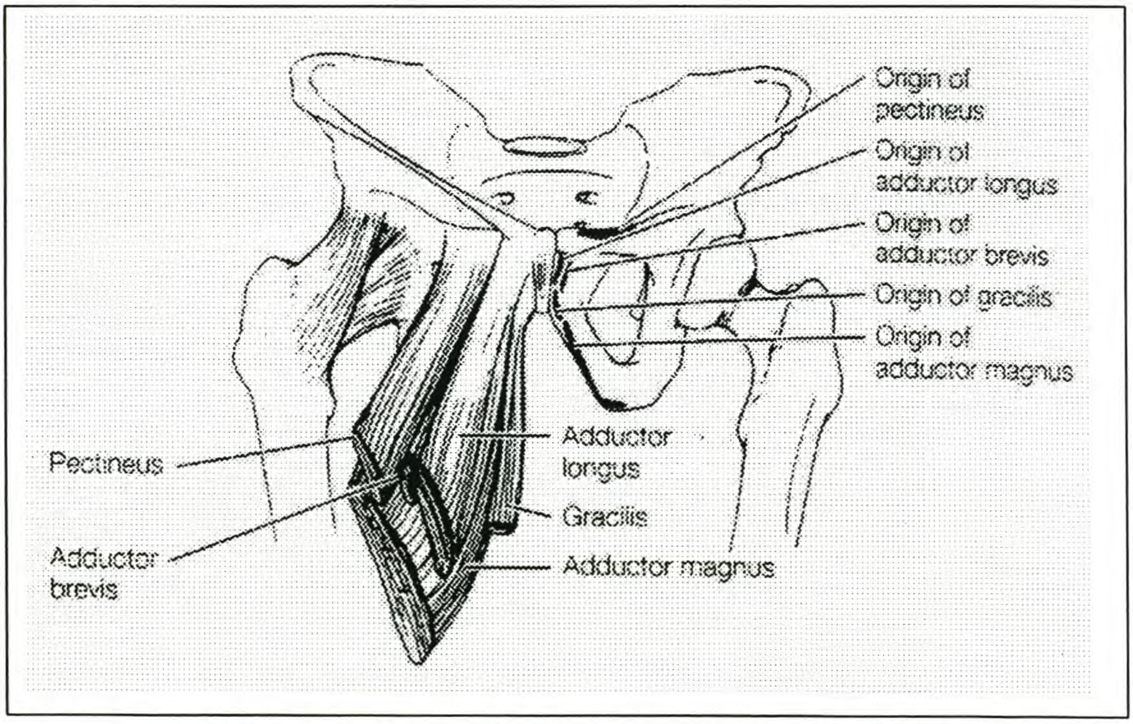


Figure 2.7: The origin of the adductor muscle group (Hasselman, *et al.*, 1995).

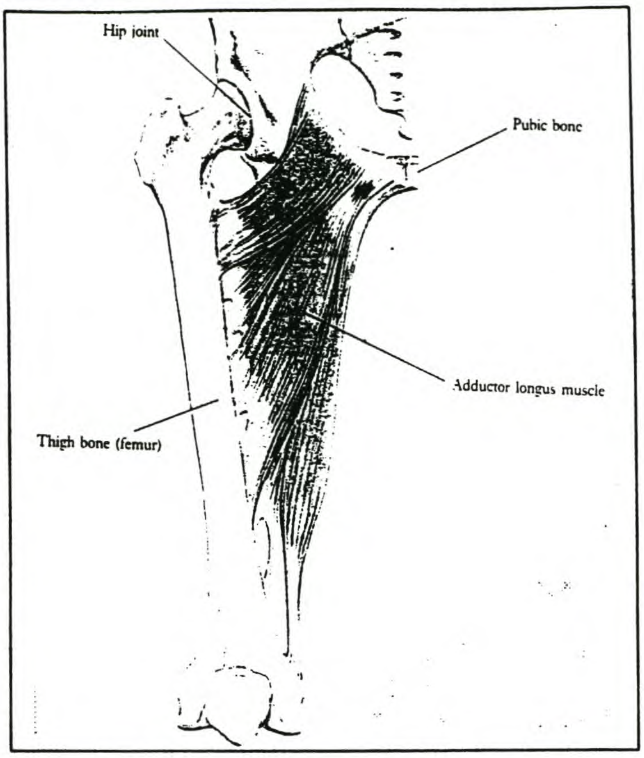


Figure 2.8: The insertion of the hip adductor muscle group which enables greater knee stability (Peterson & Renström, 1994).

It is thus clear that lateral movement training can have a positive influence on the knee, hip and posture muscles.

Although the lateral movement trainer employs the entire body for balance, the device focuses mainly on the lower body in terms of muscle strengthening and development. The slide board offers an intense aerobic and anaerobic exercise for the cardiovascular system (Smith, 1994:3).

It is important to start and end a lateral movement training session by stretching the entire body, primarily the leg muscles. It is wise to include specific stretching exercises for the hamstring and adductor muscles, which research reports to be the most affected after prolonged exercise sessions (Diener, 1994:28). The reason for this is the extensive eccentric contractions associated with lateral movement training.

2.3.5 Cardiovascular benefits and metabolic responses

With the introduction of the lateral movement trainer, questions have been raised about its effectiveness in providing a cardiovascular workout and the metabolic responses thereof.

The American College of Sports Medicine (ACSM) recommends that an appropriate exercise intensity for aerobic conditioning is between 60% to 90% of maximum heart rate, or 50% to 80% of heart rate reserve, or VO_2max (ACSM, 1995:158). The frequency of training should be a minimum of three days per week, for a duration of 20 to 60 minutes. Exercise intensity is an important variable related to the physiological benefits associated with any form of aerobic training (Williford, 1994:35).

A study done at Auburn University's Human Performance Laboratory evaluated the exercise intensity of 34 women who were participating in a sliding programme on 1.5m and 1.8m slide boards performing the standard sliding technique. The four-count movement (push-stop-push-stop) was monitored with a metronome. The subjects completed 30, 40 and 50 slides per minute.

While performing the slide exercise the subjects were connected by wiring and tubing to a metabolic measurement system, which provided data on the subjects' heart rate, oxygen consumption and number of calories burned per minute. The heart rate and oxygen consumption indicated the relative intensity of the exercise. The heart rate ranged from 143 beats per minute on the 1.5m board to 186 beats per minute on the 1.8m board. These results indicated that slide board exercise could meet, or exceed, the ACSM guidelines in terms of exercise intensity (Williford, 1994:35). It was also found that the average 60kg woman expended between 5.6 to 9.9 calories per minute.

In another investigation by Williford (1994:36) subjects were evaluated while performing different slide movements, including the standard, hip flexion, knee flexion and low-profile techniques. The hip flexion and knee flexion slide techniques were adaptations of the standard slide and required the raising of the knee (hip flexion) and bending of the knee (knee flexion) when reaching each end of the slide board. The low-profile slide was performed by lowering the body and flexing the trunk so that the cross-lateral hand contacted the endplate.

Compared to the standard technique the hip flexion and knee flexion techniques increased energy cost with approximately 16% and the low-profile technique increased energy cost with approximately 28%. These results showed that energy costs of slide board exercise could vary dramatically depending on the type of exercise manoeuvres in the above exercises. As the amount of muscle involvement increased, the energy cost too increased correspondingly.

Studying the heart rate responses during slide board exercise compared to that of running on a treadmill, Williford (1994:37) found that subjects participating in the slide board exercise experienced significantly higher heart rate responses (15%) compared to the subjects running on a treadmill at the same energy cost (Williford, *et al.*, 1995:43).

The same result has been obtained with women participating in other forms of aerobic exercise. These investigations suggest that heart rate responses from various forms of aerobic exercise may be higher than those achieved in running and walking programmes at similar intensity levels. Williford, *et al.* (1995) therefore concluded that slide board exercise could be an alternative mode of aerobic training.

Studies done at the Exercise Physiology Laboratory of the University of Nevada showed that when subjects were left to exercise at a pace that was comfortable to them, they burned 10 to 13 calories per minute on average (Diener, 1994:28). That is the equivalent of running 7.5 to 8.5 miles per hour (12km/h to 13.6km/h). It was also shown that board length, cadence and posture (the more pronounced the forward lean, the more calories burned) had an influence on caloric expenditure. It was concluded that adding arm movements like those of a speed skater (with hand weights if necessary) could meet the training needs of even the most physically fit subjects.

2.3.6 Injuries associated with lateral movement training

It was found that the most common injury sites for skaters are the knee (10% to 20%), shin (10%), ankle (16% to 37%) and spine (8% to 15%) (Teitz, 1993:255), most of which can be attributed to overuse syndrome (that is, doing too much too soon).

Anderson and Montgomery (1988) researched the physical profile of elite Alpine skiers. They found that the majority of injuries occurred at the end of the skiing day when skiers were fatigued. The optimal alignment of the lower legs was of great importance in the minimising of injury.

When looking at aerobic dance injuries, Francis, *et al.* (1985) found that overuse injuries, due to the repeated impact of the dancers' feet on firm surfaces, were the most common. The shin was the most common site of injury, with the knees and the back the next most prevalent sites.

Since lateral movement training incorporates the same techniques as the above-mentioned sports, they could serve as an indication of injuries to be expected during slide board training.

Williford, *et al.*, (1996) investigated the physiological changes and injury rates associated with lateral movement training. Twenty-five females performed slide board exercises three days per week, with each session lasting one hour, over a 10-week period. The incidence of injury was 80% Grade I injuries (experienced discomfort but did not alter daily activity), 52% Grade II injuries (had to alter or cease activity), 0% Grade III injuries (had to alter daily activity as well as exercise activity) and 4% Grade IV injuries (had to seek professional medical care).

Thus the primary injury reports were of Grade I and Grade II level of severity. The presented injuries were largely associated with delayed onset muscle soreness (DOMS) in the medial leg musculature during the first two weeks of training. The risk of incurring an injury requiring medical attention therefore appears to be quite low. However, they found that untrained women, who performed this activity at a frequency, duration and intensity similar to the present study, might experience muscle soreness during the initial period of training.

Individuals with lower-back problems are advised to maintain a straighter position on the lateral movement trainer. The slight forward lean required to maintain balance while sliding, may lead to some subjects with prior lower-back problems finding it difficult to use the device (Diener, 1994:29).

It thus seems that slide board exercise has a low injury risk due to the low shock impact on the lower extremity joints.

2.3.7 Lateral movement training mechanics

The Grade I and Grade II muscle soreness experienced during the slide board training period in the above-mentioned research, is most likely related to lateral motion exercise mechanics.

A large degree of eccentric work is performed during lateral sliding. The stance employed during slide board exercise requires the subject to maintain an *athletic posture* (for example, a lowered centre of gravity achieved by abduction and flexion at the hip and flexion at the knee and ankle). In order to maintain this position a balance is constantly sought via eccentric and concentric activation of the involved muscles. During the lateral manoeuvring, abduction and adduction occur at the hip. Femoral abductors initiate the movement. Thereafter the medial thigh muscles contract eccentrically to decelerate and stop the subject when reaching one end of the slide board. The eccentric work of the medial thigh muscles may be specifically responsible for muscle soreness.

Slide board training is particularly unique in that the dynamic work is generally performed in the lateral plane. The majority of aerobic fitness activities, including running, walking and cycling are primarily executed in the saggital plane. Even experienced exercisers therefore tend to be unaccustomed to prolonged lateral movement. The novelty of lateral movement training, in conjunction with the high degree of eccentric work in the medial thigh region, is most likely the greatest contributor to delayed onset muscle soreness (Diener, 1994:29).

In order to prevent delayed onset muscle soreness, stretching should form an integral part of the warm-up and cool-down session before and after the slide session. These stretching sessions should especially focus on the hamstring, quadricep, abductor and adductor muscle groups (see Figure 2.9a and b) (Aronen, 1997:129; Schatz, 1994:101).

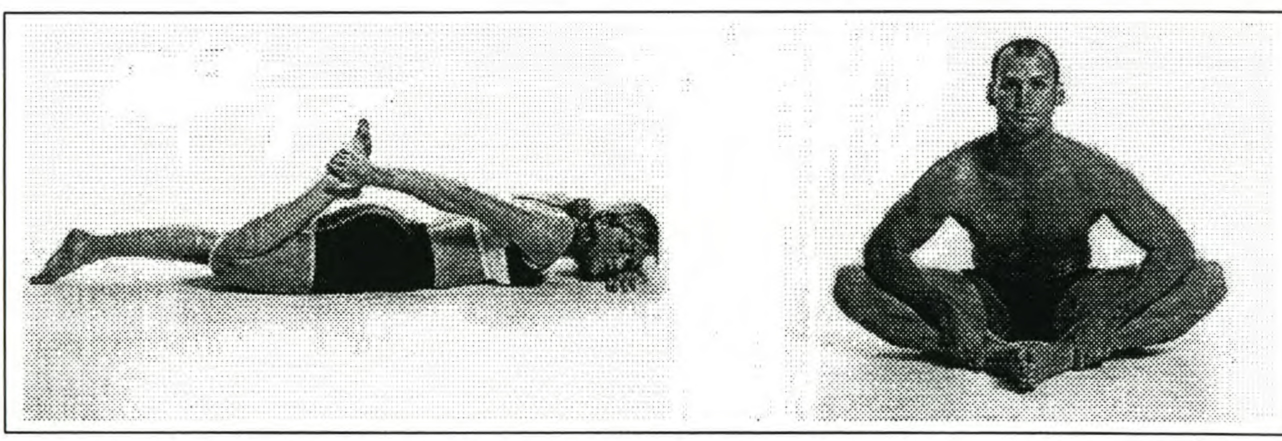


Figure 2.9: Stretches for the quadriceps (a) and adductor (b) muscle group (Peterson & Renström, 1994).

2.4 IMPLICATIONS OF LATERAL MOVEMENT TRAINING FOR ATHLETES

Slide board advocates suggest that the activity provides an outstanding cardiovascular workout – without the high impact forces characteristic of running and other sports. Supporters also contend that slide boarding strengthens muscles, tendons and ligaments on the lateral sides of athletes' hips, knees, ankles and feet – muscles and connective tissues which are important for sports such as squash, tennis, netball, hockey and rugby. There is also evidence that slide board exercise can improve athletes' overall co-ordination and balance (Anderson, 1993:3).

Critics, on the other hand, claim that slide board exercise cannot really improve fitness. Sceptical runners argue that the side-to-side motions are not specific enough to the straight-ahead (saggital plane) muscular patterns required for running.

2.4.1 Scientific confirmation

A study done at Auburn University with 20 moderately trained individuals, who moved back and forth vigorously on a slide board for 10 minutes while following a commercially produced videotape routine, showed that the heart rate averaged 87% to 91% of maximum heart rates. Oxygen consumption varied from 67% VO_2max at the beginning of the session, to 83% VO_2max at the end. This conclusively proved a 10-minute slide board session to be good aerobic exercise (Anderson, 1993:4).

In a separate study done at the Adelphi University in New York, it was found that heart rates averaged 85% to 90% of maximal in a slide session, proving that sliding is a good cardiovascular workout as well. Findings such as these indicate why the American College of Sports Medicine ranks slide board training as one of the most effective exercises for promoting cardiovascular fitness (Utsumi, 1995:6).

The Adelphi researchers also compared slide board exercise with treadmill walking. They found that slide board exercise doubled oxygen consumption and ventilation rates, and enhanced heart rates by almost 50%. It burns more calories than walking, because the feet are always in contact with the ground (as long as the standard technique is used). This constant contact forces leg muscles to continuously exert force. This in turn leads to higher energy expenditures (Anderson, 1993:4).

2.4.2 Implications for runners

It is known that elite athletes add alternative training to their normal training programme, using the muscles that actively participate in their specific sports. Top level roller skaters for instance, in addition to their classic skate training, usually do a considerable amount of cycling and running in training sessions (Martinez, *et al.*, 1993:72)

Slide board training can be an alternative to regular training, or a rehabilitative activity, for example, to injured runners. It may also help runners to run more efficiently, as explained by the following:

When running, the gluteus muscles are important, because they provide the forward propulsion whenever a foot strikes the ground (Luttgens, *et al.*, 1992:550). But runners seem to focus on the gluteus maximus muscle and forget the importance of the gluteus medius (with its origin on the external surface of the ilium and insertion on the oblique ridge on the lateral surface of the greater trochanter of the femur) (Kendall, *et al.*, 1993:221). The gluteus medius' main function is to abduct the leg, but it also stabilises the body, preventing excessive side-to-side motions during running (Anderson, 1993:5).

It is at this point that slide board training can fulfil an important role. The gluteus medius muscles are maximally fortified by slide boarding, and slide board-strengthened gluteus medius muscles should prevent energy-wasting side-to side motions of the upper body when running. Since the trunk will be vertical, there is no energy wasted on balancing the trunk while running. The body will move straight ahead and therefore running economy will be improved. By improving running economy, the runner can upgrade his or her running performance (Anderson, 1993:5).

Slide board training may also improve running capacity in another way: although most slide board movements are carried out in the frontal plane, it is possible to move on the slide board in the saggital plane, especially with the 'sliding lunge squat'. This exercise strengthens the key muscles used in running (the quadriceps, hamstrings and gluteus muscles) and increases hip flexibility, all of which should improve running economy.

It appears as though basketball, football, tennis, squash, netball, hockey and rugby players may benefit from slide board training, since all of these sports emphasise lateral movement. Lateral movement training can also serve as a change from the monotony of running, as a possible way of improving running economy and as a technique for fortifying muscles and connective tissues to prevent injury (Anderson, 1993:5).

2.4.3 Rehabilitation possibilities

The lateral movement trainer can be an integral part of a rehabilitation programme. The goal of any rehabilitative programme is to return an individual to normal, or to return the athlete to functional levels at or above pre-injury status (Reese & Lavery, 1991:23).

When recovering from an injury, the athlete is often required to rest or keep the injured body part immobilised. Rest results in changes that are not consistent with successful competition. Generally the most rapid decrements occur in cardiovascular endurance, flexibility and strength (Peterson & Renström, 1994:150).

In the past slide boards were primarily used in the late stages of lower extremity rehabilitation, particularly following knee injury or knee surgery. This was mainly because of its low-impact status (Harmer, 1991:32). As with certain upper-extremity injuries, the lateral movement trainer is an alternative method of maintaining aerobic conditioning while an individual is unable to compete. There are many ways to maintain this fitness level, but during rehabilitation variety is an important physiological aid (Reese & Lavery, 1991:24).

Although the slide board is simple in concept and design, it is not totally innocuous. Individuals with poor dynamic stability are at risk of falling, there being no handrails or other means of stabilising one self once one is sliding. A person using a slide board should therefore concentrate on what he or she is doing. The dynamic stability component of the slide board is considered not only its most obvious liability, but also one of its great assets (Harmer, 1991:32).

The lateral movement trainer also helps develop kinaesthetic awareness (i.e., control of the body throughout a movement or exercise). This is related to sensory nerve cells - proprioceptors - which relate to the understanding of body position in the environment. There are different types of proprioceptors, for example, mechanoreceptors or joint receptors, which are found in tendonous, ligamentous, muscular, capsular and periosteal tissue (Peterson & Renström, 1992:95). These receptors send information about joint angle, acceleration and deformation to the central nervous system. This is important not only for performance, but also for protection from injury. Decreased stimulation caused by rest and immobilisation will impair the normal function of these receptors. Lateral movement training allows a safe, controlled and functionally applicable method of retraining after injury (Reese & Lavery, 1991:24).

Regaining neuromuscular control, co-ordination and balance in a functional, multiplanar pattern in a controlled environment are extremely important in the transition from restricted activity to full participation. The need for stress-injured structures to increase functional capacity without aggravating the initial injury, is the rationale for the utilisation of walking, water aerobics, aqua-joggers, cycle-ergometers and stairclimbers in lower extremity rehabilitation (Utsumi, 1995:1). The low-impact, variable-demand nature of these activities, coupled with specificity in training, is in keeping with the aforementioned principle of rehabilitation. Slide boarding also meets these criteria. Based on these features and the success of slide board knee rehabilitation, physical therapists and athletic trainers are experimenting with protocols to incorporate slide boards in ankle and back rehabilitation programmes (Harmer, 1991:32).

Potential users need to be aware that despite its simplicity and the purported advantages, slide boards may not be suitable for individuals with poor lower-extremity or dynamic stability.

Anderson (1993:5) warns that slide board exercise should not be performed by individuals with knee problems, including 'sliding kneecaps' and patellar tendinitis, athletes with chronic back pain and those with foot problems, especially on the lateral side of the foot. Pre-activity screening is therefore essential (Tharrett & Peterson, 1992:27). On the other hand, runners or athletes with stress fractures in the lower part of the leg should be able to slide board successfully.

2.4.4. Special considerations and benefits

Stevens (1994:32) stresses that it is important for participants and instructors of lateral movement training to recognise the need for proper technical training in slide board exercise. Injuries may occur as a result of improper execution and body alignment. It is recommended that proper training in slide fundamentals be made a prerequisite. According to progression recommendations it is essential to allow adequate adaptation of the musculoskeletal and cardiovascular systems. Lateral movement training may not be appropriate for high-risk populations such as pregnant women, elderly adults and those with a history of lower-body joint or back problems.

Thus, if the correct procedure is followed, lateral movement training can:

- provide a much needed cross training mode in gymnasiums and aerobic venues.
- act as a preventative measure against common lateral movement injuries (for example, anterior cruciate ligament injuries).
- enhance sports, especially those which directly mimic side-to-side sliding motion.
- efficiently expend a high level of calories.
- provide high-intensity exercise with low impact and minimal joint stress.

2.5 DEPENDENT VARIABLES

For this study several dependent variables related to lateral movement training and the sport of netball have been identified. These variables will be briefly discussed.

2.5.1 Girth measurement

When skeletal muscle is subjected to a training programme of high resistance, it adapts by becoming larger (that is, grows larger in girth) and stronger (Kanehisa, *et al.*, 1997:106). This growth could be the result of either the enlargement of each muscle fibre (hypertrophy), or an increasing number of cells (hyperplasia). The latter was ruled out in the 1800s. In recent years however, several investigators have reported fibre splitting due to heavy resistance training, but no evidence of true cell division (mitosis) was found. For all practical purposes hypertrophy is still accepted as the reason for the growth of a muscle in response to heavy exercise (De Vries & Housh, 1994:426).

It has been suggested that eccentric contractions are necessary to simulate hypertrophy. Concentric training alone does not result in an increase in the size of a trained muscle (De Vries & Housh, 1994:427). Starkey, *et al.* (1996) researched the effect of resistance training volume on strength and muscle thickness. It was found that the muscle thickness change was greater for the hamstring muscle compared to that of the quadriceps muscle. The authors found this phenomenon difficult to explain. They concluded that the hamstring muscle normally performs eccentrically, acting as a brake to slow the acceleration of the leg, whereas the quadriceps muscle gets more total daily stimulation concentrically (walking up stairs, standing up and walking); thus the hamstring muscle may have greater potential for hypertrophy than the quadriceps muscle.

De Vries and Housh (1994:427) however, state that studies done by Narici and colleagues in 1989 showed that significant increases in the cross-sectional area of the quadriceps muscle followed after two months of concentric, isokinetic training. They concluded that hypertrophy does not require eccentric contractions.

Since lateral movement training specifically exercises the quadriceps and hamstring muscles (especially eccentrically), the above-mentioned aspects should be kept in mind. The measurement of girths requires great care. One of the main difficulties is locating the exact body site. The girths must be at right angles to the long axis of the body or body segment and not tilted. A steel or cloth tape may be used for measurement (Johnson & Nelson, 1979:177).

2.5.2 Weight measurement

Generally speaking, scales based on the lever system are more reliable than the spring scale. Both types, however, require periodic inspection and rather delicate handling.

The subject to be weighed should be wearing a minimum amount of clothing, such as gym shorts. No appreciable accuracy is lost if the amount of clothing is kept consistent. Consistency is the key to all measurements. The subject should be weighed at the same time of day and to the same degree of accuracy (Johnson & Nelson, 1979:166).

2.5.3 Body composition: fat percentage

Evaluation of body composition is a common and important component of overall fitness assessment. Body composition refers to the relative percentages of body weight compromised of fat and fat-free body tissue (American College of Sports Medicine, 1995:53).

Several methods for measuring body composition are available. The methods most often used are laboratory techniques (of which hydrostatic weighing is the most popular) and anthropometric techniques, which include height-weight indexes, skinfold fat, body circumferences and bone diameters (Jackson & Pollock, 1985:76).

The most feasible, reliable, valid and popular method of field estimation of body composition seems to be the skinfold technique, which is the measurement of skinfold (actually 'fatfold') thickness at specific body sites (Morrow, *et al.*, 1995:219; Jackson & Pollock, 1985:78). The principle behind this technique is that the amount of subcutaneous fat is proportional to (about 50% of) the total amount of body fat (American College of Sports Medicine, 1995:55). The measurements are performed with skinfold calipers, such as those manufactured by Lange and Harpenden.

To ensure reliability of the skinfold measurements, the researcher should have had ample practice. Morrow, *et al.* (1995:21-222) recommends the following steps for taking skinfold measurements:

- Lift skinfolds two or three times before placing the skinfold caliper and taking a measurement.
- Place the calipers below the thumb and fingers and perpendicular to the fold so that the dial can be easily read; release the caliper grip completely and read the dial one to two seconds later.
- Repeat the process at least three times; the measures should not vary by more than one millimetre.

Properly taken skinfold measures serve as a useful field estimate of body composition. It is essential though, to keep in mind that there is a standard error of estimate of up to 3.98% fat (Morrow, *et al.*, 1995:222).

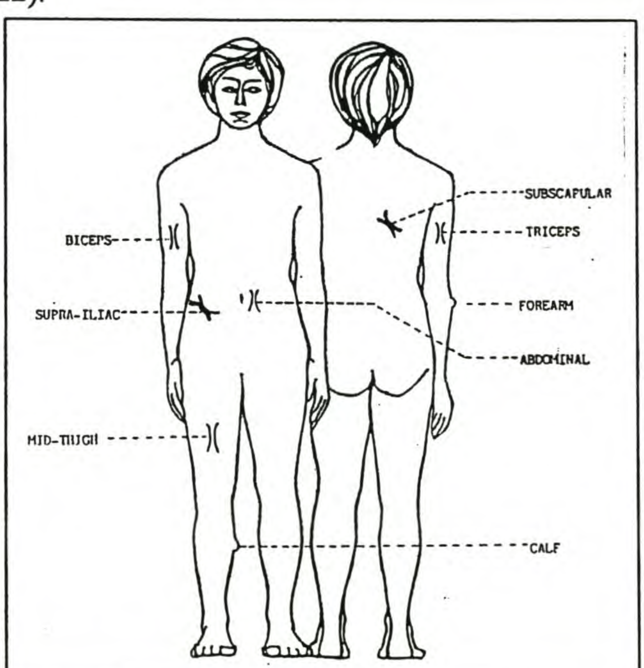


Figure 2.10: Some of the sites for taking skinfold measurements.

Skinfold measurements can thus also be used to determine body composition of subjects participating in lateral movement training research.

The only research found on lateral movement training and fat percentage was that of Smith (1994:iii), who studied the changes in leg strength and endurance, aerobic capacity and body composition during seven weeks of training on a slide board. Ten male subjects, aged 19 to 30, with an above average fitness level volunteered to participate in this study. The subjects underwent skinfold tests for body composition pre- and post-training. The average percentage body fat was 18.8% prior to training and 18.1% following the training programme, with the 0.7% difference not considered significant. According to the researcher the lack of any significant changes was expected, since no restrictions were put on the subjects' diet, which would account for the lack of percentage fat changes.

It is thus important not only to determine the percentage body fat of the subjects participating in the research in order to describe their body composition, but also to serve as an indication of the possible use of lateral movement training as a body fat reducing instrument. Indirectly it is an indication of whether lateral movement training is a good aerobic exercise, since the latter leads to the burning of calories.

2.5.4 Lateral agility

Agility may be defined as the physical ability which enables an individual to rapidly change body position and direction in a precise manner (Johnson & Nelson, 1979:215). Lateral agility is therefore the rapidity with which a lateral movement can be made and changed to the opposite direction. Since slide board training is a side-to-side exercise, lateral movement training could influence lateral agility.

Utsumi (1995) studied the effect of short-term slide board training on lower extremity lateral movement or quickness. Forty normal, healthy college students from the University of North Carolina (20 male, 20 female) between the ages of 18 and 25, participated in the study. All subjects were pre- and post-tested on the FASTEX and total transit time and average transit speed were recorded as dependent variables. The training group participated in a four-week, three times per week slide board training programme between two FASTEX instruments. Repeated-measures t-tests (α=0.05) revealed statistically significant differences within group and between groups.

Utsumi (1995) concluded that the short-term slide board training programme did significantly improve subjects' lower extremity lateral quickness by decreasing time and increasing speed of movement.

Thomas (1995) investigated the effect of slide board training as a component of pre-season conditioning on concentric and eccentric quadriceps peak torque, vertical jump height and agility. Twelve Temple University female basketball players participated in the study. In addition to pre-season conditioning, all subjects trained on the Euroglide slide board three times per week for six weeks. Agility was determined with a 40-yard multidirectional run. Subjects were allowed two agility runs during the pre- and post-test data collection sessions. The results of the two 1×2 ANOVA tests revealed significant differences at the $p < 0.05$ level in agility. The agility time decreased by 0.73 seconds after the six-week slide board training and pre-season training. Thus the results indicated the potential benefits of using slide board training as a component of a pre-season training programme.

Clarke (1996) studied the effect of a six-week slide board training programme as part of a pre-season conditioning programme on hamstring strength and agility of female college basketball players. Eight subjects participated in the slide programme administered three times a week for six weeks. Shuttle-Run and T-shuttle agility tests were completed before and after the six-week training period. Results indicated a significant decrease in T-shuttle time (7%), but not Shuttle-Run time. Clarke concluded that within the limits of the study, a six-week slide board training programme as a component of a pre-season training programme, would increase lateral agility.

A problem with the above-mentioned studies of Clarke and Thomas, is that the studies did not include a control group to monitor the influence that basketball training itself has on lateral agility. In the above conclusions the researchers assumed that it was the lateral movement training that led to improved lateral agility.

From the studies done on lateral movement training on basketball players, it is derived that slide board training may improve lateral agility in netball players as well, since netball utilises the same skills.

2.5.5 Lateral flexibility

Flexibility as a component of physical fitness, is the ability of an individual to move the body and its parts through as wide a range of motion as possible without undue strain to the articulations and muscle attachments (Hubley-Kozey, 1991:309; Johnson & Nelson, 1979:76). Lateral flexibility therefore refers to flexibility in the frontal plane. Flexibility allows a higher degree of freedom and ease of movement, coupled with important implications for greater safety with regards to injury. Literature indicates that flexibility is of interest to coaches, physical educators, sports scientists and rehabilitation therapists. Generally they agree that flexibility is important to athletic performance, injury prevention and rehabilitation.

Two types of flexibility tests are defined:

1. Relative flexibility tests are designed to be relative to the length or width of a specific body part. These tests not only measure the movement, but also the length or width of an influencing body part.
2. Absolute flexibility tests only measure the movement in relation to an absolute performance goal.

Measurement of flexibility can also be done through the use of direct or indirect methods:

1. Direct methods are utilised by measuring angular displacements between adjacent segments (relative angle) or from an external reference (absolute angle). The unit of measurement is degrees and is usually determined utilising a protractor, goniometer or flexometer (Hubley-Kozey, 1991:330).
2. Indirect methods usually involve linear measurement of distances between segments, or from an external object. The unit of measurement is millimetres (Hubley-Kozey, 1991:330).

2.5.6 Dynamic balance

Two types of balance are identified, namely static balance and dynamic balance. Static balance may be defined as that physical ability which enables an individual to hold a stationary position.

Dynamic balance is the ability to maintain balance during vigorous movement, as in jumping a fence or leaping from stone to stone while crossing a stream. There is evidence to indicate that the ability to balance easily, whether statically or dynamically, depends upon the following:

- the function of the mechanisms in the semicircular canals,
- the kinaesthetic sensations in the muscles, tendons and joints,
- the visual perception while the body is in motion,
- the ability to co-ordinate these three sources of stimuli (Johnson & Nelson, 1979:227).

Lateral movement training is a dynamic exercise and literature concludes that lateral movement training enhances balance, it was therefore decided to test the subjects' dynamic balance abilities with the Modified Bass Test.

2.5.7 Heart rate

Recently, the use of heart rate (HR) to estimate energy expenditure has become increasingly popular (Gretebeck, *et al.*, 1991:629). Parker, *et al.* (1988:230) state that target heart rate specifically has been extensively used to monitor exercise intensity of both running and aerobic dance. The use of target heart rate is based on the assumption that heart rate increases proportionally to increases in oxygen consumption (VO2). This relationship is essentially linear and proportional during running and cycling, but has not been well established for aerobic dance exercise.

Scharff-Olson, Williford and Smith (1992) investigated the relationship between heart rate and oxygen consumption during aerobic dance exercise. Eleven females completed 20-minutes of aerobic dance with continuous monitoring of heart rate and oxygen consumption. The study showed that traditional methods of prescribing target heart rates, which are based on heart rate-oxygen consumption relationships derived from treadmill running, could underpredict appropriate exercise intensity for aerobic dance. The aerobic dance heart rate-oxygen consumption relationship indicated that heart rates must represent nearly 80% of heart rate maximum in order to cross the accepted training threshold for oxygen consumption.

Williford, *et al.* (1989) also concluded that heart rate may not be an accurate indicator of energy expenditure during aerobic dance. Individual analyses of heart rates indicated that some of the subjects were working at a heart rate approaching their maximum without any undue exhaustion or discomfort.

The higher heart rates associated with aerobic dance could be related to one or more of the following factors, which may elevate heart rate without a corresponding increase in oxygen consumption:

- Attempts to follow the instructor or to keep up with the group places additional stress on the participant.
- The dancers become involved with the music and forget how hard they are working (i.e., a lack of concentration and attention).
- The dance often requires vigorous use of the arms and overhead arm movements.

Since lateral movement training is a form of aerobic dance exercise, it is important to consider the above-mentioned aspects about heart rate.

In a study done by Martinez, *et al.* (1993), physiological comparisons were made between roller skating, treadmill running and ergometer cycling. Results showed an individual linear heart rate-workload relationship. The average values for the three subjects showed that at a given stage heart rate was higher during roller skating than during treadmill running or cycling. Since lateral movement training mimics roller-skating, the same tendency may be expected.

The American College of Sports Medicine (1995) recommends that exercise intensity should be between 60% to 90% of maximum heart rate. The two most common formulae for predicting maximum heart rate in adults are:

$$220 - \text{age (years)}$$

or

$$210 - 0.65 \times \text{age (years)}.$$

The standard deviation for each formula is 10 beats per minute (Wasserman, *et al.*, 1994:119).

2.5.8 Isokinetic testing

2.5.8.1 Basic principles

The purpose of performing dynamic muscle performance testing is multi faceted. The primary purpose is to obtain an objective record of the musculotendinosis unit and, to a lesser extent, information about neuromuscular integrity. By obtaining this record, the tester is able to establish a database for reassessment at a later date in order to document treatment effectiveness (Wilk, 1990:125).

Morrow, *et al.* (1995:227) state that dynamic muscle actions are defined and categorised by the following specific terms:

Concentric contraction - muscle generating force as it shortens
Eccentric contraction - muscle generating force as it lengthens
Isokinetic contraction - muscle generating force at a constant speed throughout a full range of motion (limb movements around a joint)

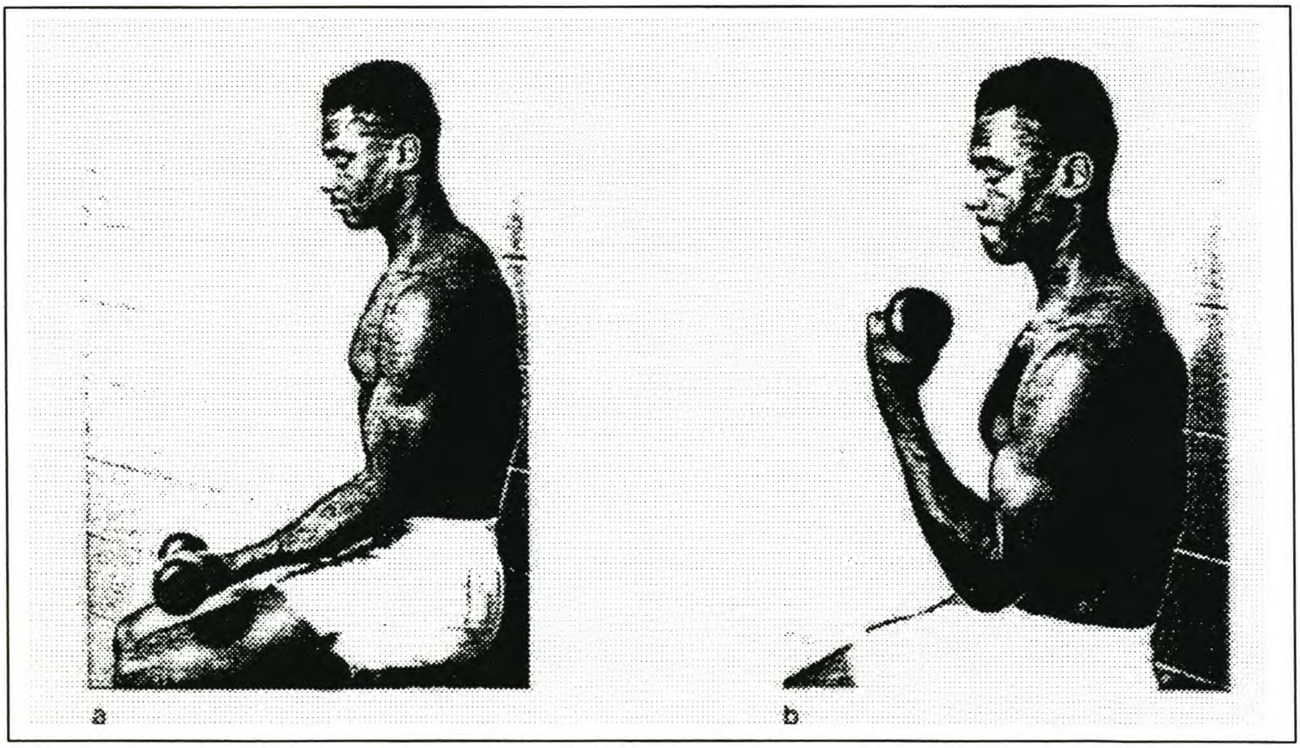


Figure 2.11: The biceps brachii before (a) and after (b) a concentric contraction (Perrin, 1993).

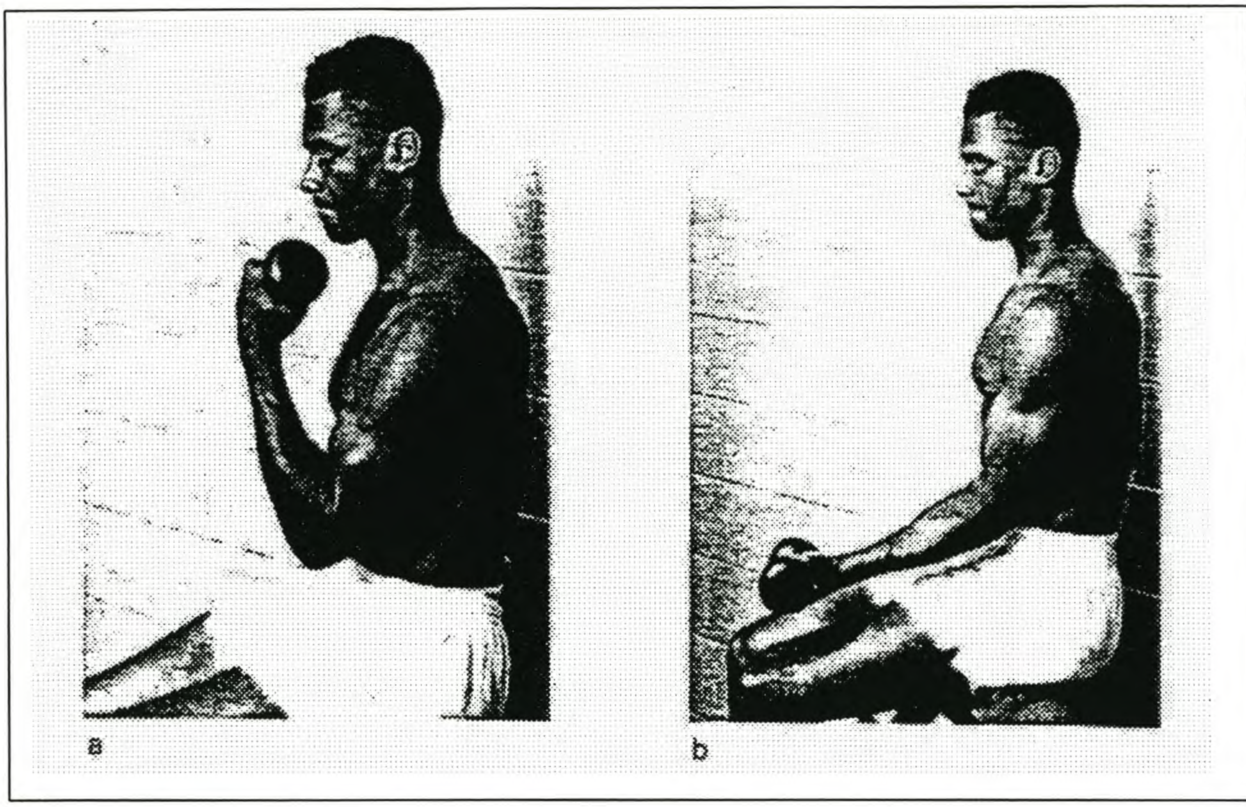


Figure 2.12: The biceps brachii before (a) and after (b) an eccentric contraction (Perrin, 1993).

One of the means available for testing dynamic muscle actions, is the isokinetic dynamometer.

The isokinetic dynamometers has been extensively used for evaluation of isolated muscle performance. The theory behind the isokinetic technique is well founded in biomechanical and physiological principles, featuring control of velocity of movement. In general isokinetic devices and test protocols for measurement of isokinetic muscle performance demonstrate high reliability (Westblad, *et al.*, 1996:134).

The term isokinetics is defined as the dynamic muscular contraction when the velocity of movement is controlled and maintained at a constant level by a special device. The resistance of the device is equal to the applied muscular torque over the range of the movement (Sale, 1991:30). Isokinetic movements require the use of an electromechanical device capable of maintaining the velocity of movement at a constant level. The velocity control mechanism of the dynamometer is usually an electronic servomotor or a hydraulic valve. The velocity of movement is pre-set and the control mechanism is activated only when the moving limb attains the pre-set velocity. Any increase in muscular torque above this level, results in the development of an equal-magnitude resistance force by the control mechanism of the dynamometer (Baltzopoulos & Brodie, 1989:102).

Baltzopoulos and Brodie (1989) also state that muscular force varies at different joint-angles, because of different biomechanical properties of the musculoskeletal system. With the isokinetic method, , the resistance of the dynamometer is proportional to the muscular capacity at different joint angles if maximum force is applied to the dynamometer through a range of movement, offering optimal loading of the muscles in dynamic conditions. Furthermore, isokinetic dynamometers, unlike gravity-loaded systems, do not store potential energy and therefore the return movement does not require eccentric contraction to control the return of the limb-lever arm system to the initial position.

2.5.8.2 The Kinetic Communicator

The Kinetic Communicator Exercise System (Kin-Com) is a hydraulically driven, microcomputer-controlled device for the test, measurement and rehabilitation of human joint function. The Kin-Com user performs a movement, or series of movements against a resistance provided by the machine via a rotating lever arm system.

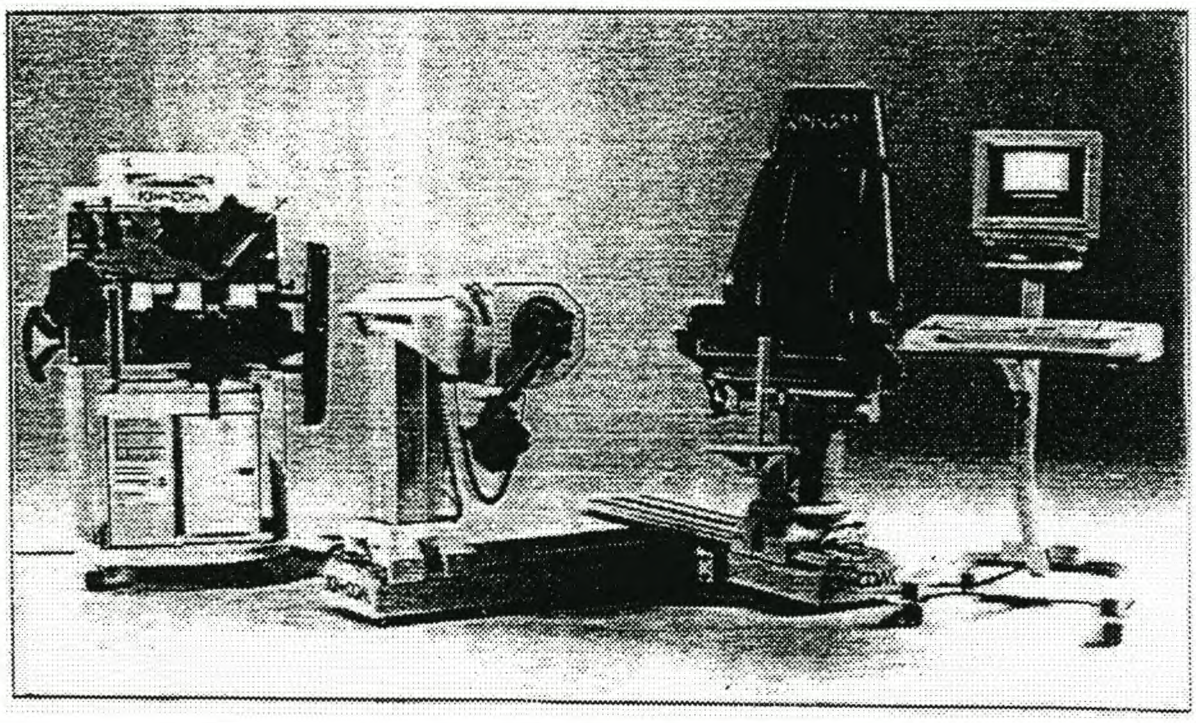


Figure 2.13: The Kin-Com.

Control of the Kin-Com is accomplished through feedback loops, which monitor the position and speed of the lever arm and the force being exerted by the user. The device utilises a strain gauge bridge for force measurement and a bar-encoded shaft for position and speed measurements (Farrell & Richards, 1986:44).

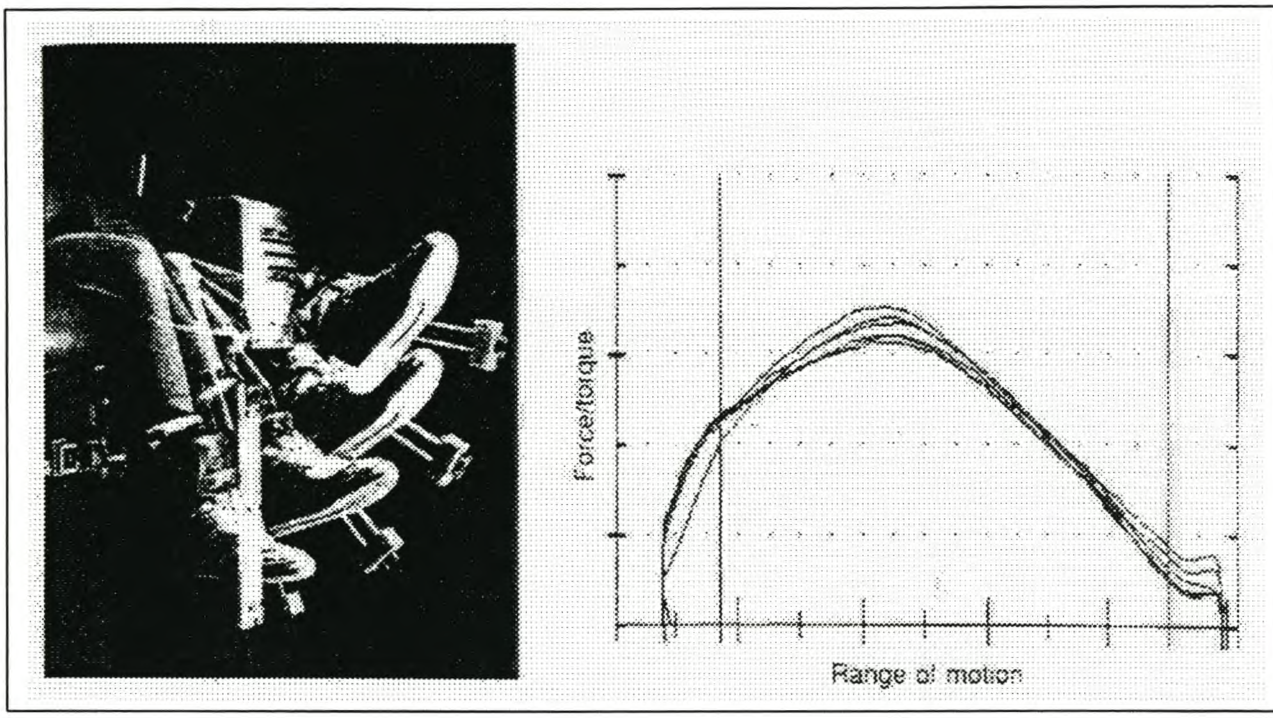


Figure 2.14: The knee flexion/extension action and the accompanied computer graph (Perrin, 1993).

The most frequently used isokinetic measurement in clinical and scientific work has been peak torque (unit: Newton meters).

2.5.8.3 Factors influencing isokinetic testing

- Education, familiarisation and warm-up

Isokinetic resistance is a strange sensation. Thus, before any test, it is very important that the subject has enough time to familiarise himself or herself with the system and the angle velocities. If this is not done, it will lead to the underestimation of the true performance. In other words, the subject will still be in the steeply ascending part of the learning curve during the actual testing situation (Kannus, 1994:S14).

The subjects must be instructed to exert maximum effort throughout the full range of motion and told that the range of motion is controlled by the dynamometer (Westblad, *et al.*, 1996:135).

- Stabilisation and positioning

Stabilisation and positioning of the body are critical factors affecting both the reliability and validity of tests of muscular performance. Inadequate stabilisation of the trunk or proximal segment of the body, or both, may limit the forces that adjacent muscles can apply to move more distal segments. Thus the true performance may be underestimated (Kannus, 1994:S14). In order to eliminate the influence of upper extremities during the testing of lower extremities' muscles (for example the hip and knee joints), the arms should be crossed on the chest. The subject is also stabilised around the waist and torso areas. It is also crucial that the rotating axis of the joint and that of the dynamometer are aligned (Sale, 1991:60).

- Gravity correction

During isokinetic testing of movements in the vertical plane (for example knee flexion-extension), forces acting on the limb-lever system are muscular, as well as gravitational force. They are generated by the mass of the limb and the lever arm. If gravity correction is not administered, the torque registered by the dynamometer will not be the actual muscle torque, but the torque generated by the resultant of the muscular and gravitational forces (Baltzopoulos & Brodie, 1989:103).

- Test protocols

A wide variety of test protocols exist for the evaluation of isokinetic torque. Several essential components must be kept in mind however to ensure optimal stability and reliability.

- **Warm-up**

Every test protocol should start with a warm-up session, consisting of maximum and submaximum repetitions. Perrin (1993:48) found that three submaximal warm-up repetitions are necessary to ensure stability of the measurements. Good reliability for this protocol was also found.

- **Rest**

The protocol must also include a rest period between every set of test repetitions. Studies showed that rest periods lead to greater isokinetic force production and reliable measurements (Perrin, 1993:49).

- **Test velocity**

A test velocity of 60° per second is acceptable (Perrin, 1993:49).

- **Test repetitions**

Several contractions are necessary before, regardless of the test velocity, a true maximum value is produced. A maximum contraction is usually reached between two to six contractions. The software of the Kin-Com evaluates torque by utilising the visual overlay technique. Every curve can be either accepted or rejected until a true maximum curve is produced.

- **Verbal encouragement**

The use of verbal encouragement can have a dramatic influence on the capacity to produce a maximum effort. Verbal encouragement will probably stimulate the production of a maximum effort, provided the encouragement is constant and consistent.

- **Visual feedback**

With every isokinetic attempt a visual, digital or numeric representation of the torque curve is shown on the monitor. Visual feedback or knowledge of the results can lead to better maximum contractions (Perrin, 1993:50).

It is necessary to apply the above mentioned components in striving for a true maximum effort from the subject. Keep in mind that the success of the test depends solely on the willingness of the subject to exert a maximum effort (Malone & Sanders, 1993:172; Shields, *et al.*, 1985:49).

Burnette, Betts and King (1990) studied the reliability of isokinetic measurements of the hip muscle torque in young boys. The Cybex II isokinetic dynamometer was used to test 29 healthy boys of six to 10 years of age, twice at one- to two-week intervals. Torque of the hip flexors and extensors and hip abductors and adductors was assessed at angular velocities of 30° and 90° per second. Relatively low reliability was found in hip abductors and adductors, but could be explained. The subjects were not always tested by the same person and the verbal commands were not always consistent from test one to test two. A lack of precision in determining the end points of the hip abduction range of motion was a major variable that was not controlled. The two or three submaximal repetitions used to familiarise the boys with the test procedure may have been inadequate for learning to take place. They concluded that greater control over the variables could have led to better results.

The above study thus shows the importance of the previously mentioned components during isokinetic testing.

♦ Isokinetic testing and lateral movement training

Smith (1994) researched the changes in leg strength and endurance during seven weeks of slide board training. Ten male subjects, aged 19 to 30, completed strength and endurance tests on knee extension and flexion, hip extension and flexion and hip abduction and adduction. Significant increases were found for left leg flexion endurance following the training (5.0 seconds versus 6.2 seconds, $p = 0.0181$). These results may have been due to the subjects being already highly trained and the exercise intensity on the slide board being too low.

Thomas (1995) studied the effect of slide board training as a component of pre-season conditioning on concentric and eccentric quadriceps peak torque. The Biodex B-2000 Isokinetic Dynamometer was used to collect right quadriceps peak torque data at 120° per second through a 90° range of motion. Concentric and eccentric data collection were randomly ordered and a 10-minute rest was scheduled between test modes for the 12 Temple University female basketball players. Eccentric quadriceps peak torque values were greater than concentric quadriceps peak torque values before and after the six-week slide board training and pre-season training. Concentric and eccentric quadriceps peak torque means also revealed greater peak torque generation in the post-test than in the pre-test.

A problem with Thomas' research is that the primary muscles used in lateral movement training, namely the hip abductors and adductors were not tested.

Clarke (1996) studied the effects of a six-week slide board training programme as part of a pre-season conditioning programme for hamstring strength and agility. Eight Temple University female basketball players were tested for concentric and eccentric hamstring peak torque on the Biodex B-2000 Isokinetic Dynamometer at 120° per second. Results indicated a significant increase between the pre- and post-tests in concentric hamstring peak torque production (11%), but not eccentric hamstring peak torque production.

It must be stated that the significant differences found by Thomas (1995) and Clarke (1996) could have also been the result of basketball training during the pre-season.

2.6 NETBALL

The ability to move laterally quickly is important in activities involving cutting and planting, such as racquet sports, soccer, basketball, etc. Netball also incorporates these skills.

2.6.1 Netball skills

Netball is a game that demands rapid acceleration to 'break free' from an opponent. It also requires sudden and explosive changes in direction, combined with elevating leaps to receive a high pass, intercept a ball, or to rebound after an attempted goal (Steele, 1990:89).

According to Cornwell (1992:14) the skills involved in netball can be divided into two categories:

Primary skills	Secondary skills
Footwork	Getting free
Catching	Marking
Throwing	Shooting
	Throw-up

Since lateral movement training primarily works with the frontal plane, the netball skills that may contain movement in the frontal plane are the primary skill of 'footwork' and the secondary skill of 'getting free'.

2.6.1.1 Footwork

As in all games, good footwork is the basis of good play. The player needs the ability to:

- sprint
- change direction at speed
- swerve and stop
- leap high in the air in any direction off either or both feet
- pivot in the air or with one foot on the ground
- catch a ball and pass it within three seconds
- obey the footwork rule (Miles, 1981:44).

Miles (1981) advises the player to practise swerving from side-to-side while running to develop good body mobility, which loads the medial and lateral thigh and knee area with added tension.

Thomas (1985) states that skilled play with the footwork rule means:

- achieving nearly perfect balance on one foot,
- achieving full control with the help of the second foot,
- using the second foot for another movement to help a change of direction and throwing.

As was outlined earlier in this chapter, advocates state that lateral movement training enhances balance, and since balance forms the basis of good footwork, the assumption can be made that lateral movement training may improve the footwork of a netball player.

2.6.1.2 Getting free

One of the aspects of 'getting free' is the technique that entails sudden sprinting and change of direction. This involves taking an opponent in one direction and then, with a sudden braking movement of the leading foot, changing direction. If the first change does not result in getting free, another change of direction should be made until a successful result is obtained.

If the direction change is not sudden enough and does not result in freedom, Cornwell (1992) advises the coach to make sure that the knee of the breaking foot is bent and that the body weight does not advance over this foot. It is this bending of the knee (eccentric contraction) that absorbs the pace of the movement prior to the change and it is the spring from which the change of direction comes.

During lateral movement training there is a constant change of direction from side-to-side, while the knee is bent and the weight is slightly forward. Lateral movement training can thus provide functional training for the netball player who needs to improve her direction-changing skill.

2.6.2 Movement patterns of netball players

Steele and Chad (1992) analysed the movement patterns of netball players during matchplay. Using video cameras they recorded netball matches during which the opponents were matched in ability level as closely as possible and all the players maintained the same playing position throughout the game.

Movement patterns demonstrated by the players were classified into the following categories:

<u>Locomotor activities</u>:

Standing:	no locomotor activity
Walking:	strolling locomotor activity in either a forward, backward or sideways direction
Jogging:	slow running action where there was no specific goal and no obvious acceleration
Running:	a fast running action with distinct elongated strides
Sprinting:	effort and purpose running at maximum speed and full effort
Shuffling:	a sideways movement of the body using a shuffling action of the feet

Statistical analysis of the data revealed the movement patterns performed during matchplay varied significantly from position to position – a fact which must be taken into consideration when designing individual and team training programmes for netball players.

Steele and Chad (1992) found that centres tended to jog, run and shuffle a significantly greater number of times with a corresponding greater percentage of their game spent jogging, running and shuffling than most other positions. Wing defence performed a high number of shuffles and spent significantly less time per stand than goal shooters, goal attacks or goalkeepers.

The implications for centre court players (centre, wing attack and wing defence) were that they should increase the number of repetitions of shuffles (frontal plane movements) during practises.

2.6.3 Biomechanical factors in netball

Biomechanical information can be used to refine the existing techniques of experienced netball players so that they may achieve optimal technical performance of game skills, while minimising the potential for injury.

Steele (1990) investigated the biomechanical factors affecting performance in netball players. She found that netball has a reputation for being a game with the potential to cause injury; a game that has been described as designed for the destruction of knees and ankles. A high incidence level of injuries existed – especially lower extremities, in particular ankle injuries. The majority of injuries occurred in the highest grade (A grade).

Steele (1990) found that 12% of the injuries occured when players attempted to land, to dodge or pivot and through accidental slipping or tripping. It was also stated that these injuries were the result of neuromuscular co-ordination inadequacy at the time of the injury.

Steele and Lafortune (1989) studied the ground reaction forces generated at landing by 10 skilled players performing an attacking netball movement pattern. The purpose of the study was to identify a landing technique that would minimise the stress on the musculoskeletal system after receiving a pass. It was concluded that players should adopt the following technique motions:

- Land with the foot neutrally aligned to eliminate excessive ankle abduction-adduction, internal rotation or dorsiflexion.
- Ensure adequate hip flexion (approximately 33° at foot-ground contact) and adequate knee flexion (approximately 17° at foot-ground contact).
- Reduce the foot-hip displacement by eliminating an exaggerated 'striding out' position often adopted at landing by netball players.

Thus, by strengthening the hip flexors, abductors, adductors, knee flexors and ankle stabilisers, the above-mentioned techniques can be implemented to reduce the risk and incidents of injuries.

Lateral movement training strengthens the hip flexors, abductors, adductors, knee flexors and ankle stabilisers and could therefor play an important role in the achieving of excellent techniques, which will lead to the prevention of netball injuries.

2.7 CONCLUSION

The literature reviewed above shows the necessity of testing the identified variables associated with lateral movement training and the application thereof on netball - a sport which emphasises movements in the frontal plane.

CHAPTER THREE

METHODS AND PROCEDURES

3.1 INTRODUCTION

This chapter describes the methodological framework of the study. The different tests and measurements as well as the sample, inclusion criteria and data analyses are described. An outline of the exercise session is also given as an appendix.

3.2 AIM

The aim of the study is to prove that lateral movement training using a slide board will significantly influence the following physiological components identified as an important part of netball:

- Weight
- Body fat percentage
- Lateral agility
- Lateral flexibility
- Dynamic balance
- Concentric and eccentric quadriceps and hamstring strength
- Concentric and eccentric hip abductor and adductor strength

3.3 HYPOTHESIS

It is hypothesised that lateral movement training using a slide board will influence the above-mentioned physiological components in netball players significantly.

3.4 SAMPLE

The original group consisted of 29 female netball players. Only 23 completed the exercise programme. Six subjects withdrew from the programme due to injuries.

All subjects were students from the University of Stellenbosch. Their age ranged from 18 to 24 years. All subjects were healthy individuals (no current hip, knee and ankle problems or injuries). To confirm their health status, the subjects underwent a medical evaluation consisting of a background check (medical history), physical examination (height, weight, sitting blood pressure and heart rate) and orthopaedic assessment.

Subjects were divided into three groups:

- Group 1: healthy female netball players (N=5) from the 1st and 2nd netball teams of the Maties Netball Club of the University of Stellenbosch, who are the 1999 club champions of their league.

- Group 2: healthy female netball players (N=9) from the 1st and 2nd netball teams of the residence Nerina. To minimise the independent variables all the subjects were from the same residence.

- Group 3: healthy female netball players (N=9) as the control group. N=5 had the same characteristics as subjects from group 1 and N=4 had the same characteristics as subjects from group 2.

Groups 1 & 2 participated in a six-week slide board-training program. Groups 1, 2 & 3 participated in the pre- and post-test.

3.5 INCLUSION CRITERIA

"Apparently healthy individuals" who (1) play in the 1st or 2nd netball teams of the Maties Netball Club or of the residence Nerina, (2) who have no recent history (past four months) of lower extremity musculoskeletal injury (any physical debilitation or pathology of the hip, thigh, knee, leg, ankle or foot). A pre-test questionnaire (see Appendix A) was completed by each subject and prior to participation an informed consent form (see Appendix B) was read and signed as recommended by the American College of Sports Medicine.

The physical characteristics of the subjects are presented in the table below.

Table 1,2 &3: Physical characteristics of the subjects.

TABLE 3.1: Subject characteristics of Group 1

Subject	Age	Height	Heart Rate	BP sistolic	BP diastolic
1	20	1.843	66	98	62
2	23	1.688	66	120	60
3	19	1.76	60	105	72
4	24	1.676	72	98	68
5	20	1.648	60	110	65
Mean	21.2	1.723	64.8	106.2	65.4
S.D.	2.167948339	0.078784516	5.019960159	9.230384607	4.774934555

TABLE 3.2: Subject characteristics of Group 2

Subject	Age	Height	Heart Rate	BP sistolic	BP diastolic
1	20	1.793	84	122	78
2	19	1.671	60	120	68
3	19	1.61	78	116	66
4	19	1.613	72	94	68
5	21	1.63	92	92	60
6	21	1.677	78	126	82
7	19	1.65	90	118	78
8	19	1.684	90	120	78
9	21	1.654	66	110	68
Mean	19.77777778	1.664666667	78.88888889	113.1111111	71.77777778
S.D.	0.971825316	0.055027266	11.27435635	12.21110606	7.378647874

TABLE 3.3: Subject characteristics for Group 3

Subject	Age	Height	Heart Rate	BP sistolic	BP diastolic
1	19	1.85	60	120	72
2	19	1.75	90	102	72
3	18	1.803	66	110	62
4	18	1.735	60	106	58
5	20	1.65	72	98	60
6	20	1.61	60	118	64
7	20	1.723	78	112	66
8	20	1.65	66	100	68
9	20	1.61	66	110	65
Mean	19.33333333	1.709	68.66666667	108.4444444	65.22222222
S.D.	0.866025404	0.085024996	10	7.666666667	4.893306085

3.6 RESEARCH DESIGN

The research design for the study consisted of three phases:

- **Phase one** was the initial testing period (two weeks). The subjects were tested for weight, body fat percentage, heights, girths, lateral agility, lateral flexibility, dynamic balance and upper leg strength.

- **Phase two** consisted of a six weeks of lateral movement training with a slide board. The subjects exercised three times per week. Each session consisted of a 10-minute warm-up, a 30-minute slide session and a 10-minute cool-down. The subjects exercised in groups of two and followed a six-week pre-recorded slide training video in which the exercises demonstrated gradually increased in intensity. The instructor was a trained and qualified slide board instructor.

- **Phase three** was the post-testing period (two weeks) which was a duplicate of phase one.

After obtaining the necessary consent from the Department of Human Movement Studies of the University of Stellenbosch, as well as al the test centres involved, the subjects were submitted to the research design. All subjects were tested and measured in the Biokinetics Laboratory and laboratory extension during April 1999. Six weeks later, at the beginning of June 1999, they were again tested and measured.

To ensure reliability the researcher applied all the tests and measurements personally.

3.7 INSTRUMENTS AND DATA COLLECTION PROCEDURES

The following instruments were used:

3.7.1 Questionnaire with biographical information

A questionnaire was drawn up to obtain information on the subjects' sporting background, injury background as well as daily sleeping and eating habits (see Appendixes A).

3.7.2 Blood pressure and heart rate in a sitting position

After allowing the subject to sit down for two minutes to allow the heart rate and blood pressure to stabilise, the blood pressure was measured with a Baumano sphygmomanometer. The cuff was wrapped firmly around the left upper arm at heart level, and aligned with the brachial artery. A standard stethoscope was placed below the antecubital space over the brachial artery. The cuff was quickly inflated to ± 200 mmHg and the pressure then slowly released, with the researcher noting when the thumping sound started (systolic blood pressure) and disappeared (diastolic blood pressure).

The heart rate was recorded with a Tritech Sports Timer over a period of 10 seconds and converted to beats/minute.

3.7.3 Weight

Weight was measured with a Krups scale (maximum = 130kg) while the subject was bare footed and lightly clothed.

3.7.4 Heights

Stature, trochanterion and tibialis externum heights were measured with a Harpenden digital anthropometer. The stature is measured from the highest point of the head in the median saggital plane, to the soles of the feet. The barefooted subjects were instructed to stand erect with heels, buttocks, upper back and rear of the head in contact with the vertical section of the stadiometer. Before taking the measurement, the subject was instructed to inhale deeply and stretch upwards to the fullest extent.

Trochanterion (the highest point upon the greater trochanter) and tibialis externum (the highest point on the lateral border of the head of the tibia) were located, marked and the heights measured with the Harpenden digital anthropometer while subjects were still in the above-mentioned position.

3.7.5 Girth measurements

The girth measurements of the right and left thigh, as well as the right and left calf were measured with a Tailorform needlework measureband. The girth of the thigh was measured 10 centimetres above the tibialis externum point. The calf girth measurement was taken at that point where the circumference was at its widest.

3.7.6 Body fat percentage

Skinfold measurements were recorded at the Triceps-, Biceps-, Subscapular-, chest, axilla, Supra-iliac, abdominal, thigh and calf sites with a Harpenden skinfold calliper with a constant jaw pressure of 10g/square millimetre. All measurements were taken on the right hand side if the subject was right handed and vice versa.

The Jackson-Pollock body composition program, Metcalc (Metabolic calculations in exercise and fitness), was used to determine body fat percentage (seven-site option).

An example of what the display on the computer screen looked like when using the Metcalc computer program to calculate the body composition:

BODY COMPOSITION (JACKSON-POLLOCK)	
ENTER YOUR NAME:	**Mary**
ENTER YOUR SEX:	**F**
ENTER YOUR WEIGHT:	**117.04**
ENTER YOUR AGE:	**27**
ENTER SKINFOLDS:	
Supra-iliac:	**14 mm**
Triceps:	**14 mm**
Thigh:	**40 mm**
BODY DENSITY	= 1.0388 gm/cc
PERCENT FAT	= 26.5 %
Fat Wgt	= 31.01 lb.
Lean Wgt	= 86.02 lb.

Figure 3.1: Computer display (The data typed in for every individual is indicated in bold.)

3.7.7 Lateral agility

The Side-Step-Test was used to measure the rapidity with which lateral movement can be made and then changed in the opposite direction (Johnson & Nelson, 1979). A Sheffield-Chesterman yardstick was used to measure the area for the test.

From a standing position astride the centre line, the subjects was instructed to [see Figure 3.1 (a)] side-step to the right on the signal "go" until the subject's foot touched or crossed the outside line. (b) The subject then side stepped to the left until the subject's foot touched or crossed the outside line to the left. (c) The subject repeated these movements as rapidly as possible for 10 seconds (time measured with a Tritech Professional Sports Timer). Each movement from the centre line across a marker counted as one. Penalties were given each time one foot crossed over the other.

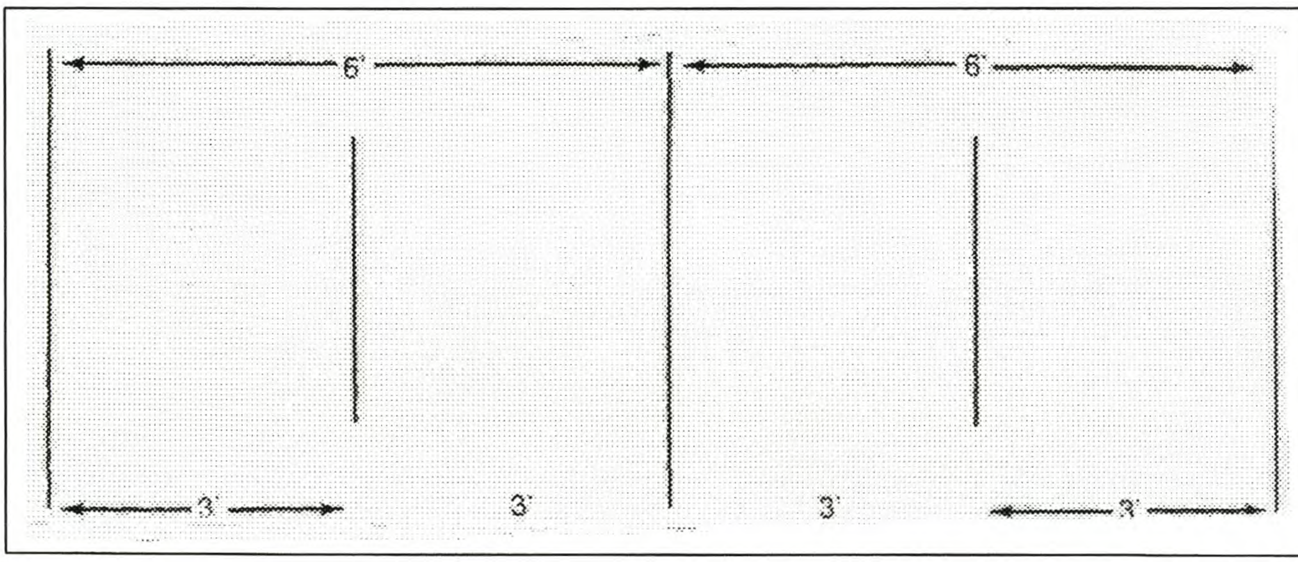


Figure 3.2: The floor pattern for the Side-Step-Test (Johnson & Nelson, 1979).

Each subject was given two chances and the best score was taken as an indication of lateral agility.

3.7.8 Lateral flexibility

Lateral flexibility was measured by using a custom-made protractor with adjustable markers that move through a 90° radius to the right and left (see Figure 3.2). Subjects were instructed to position themselves (their centre) on the centre (↑) of the protractor, with the right leg next to the marker so that the latter pointed at 0°. The left and right legs were aligned and the subjects stabilised themselves with their hands pressed against the board while keeping their arms at their sides. The subjects pushed the marker as far right and left (respectively) as possible and the range of motion (in degrees) was recorded. The procedure for each side was repeated three times and the best score was taken as an indication of lateral flexibility.

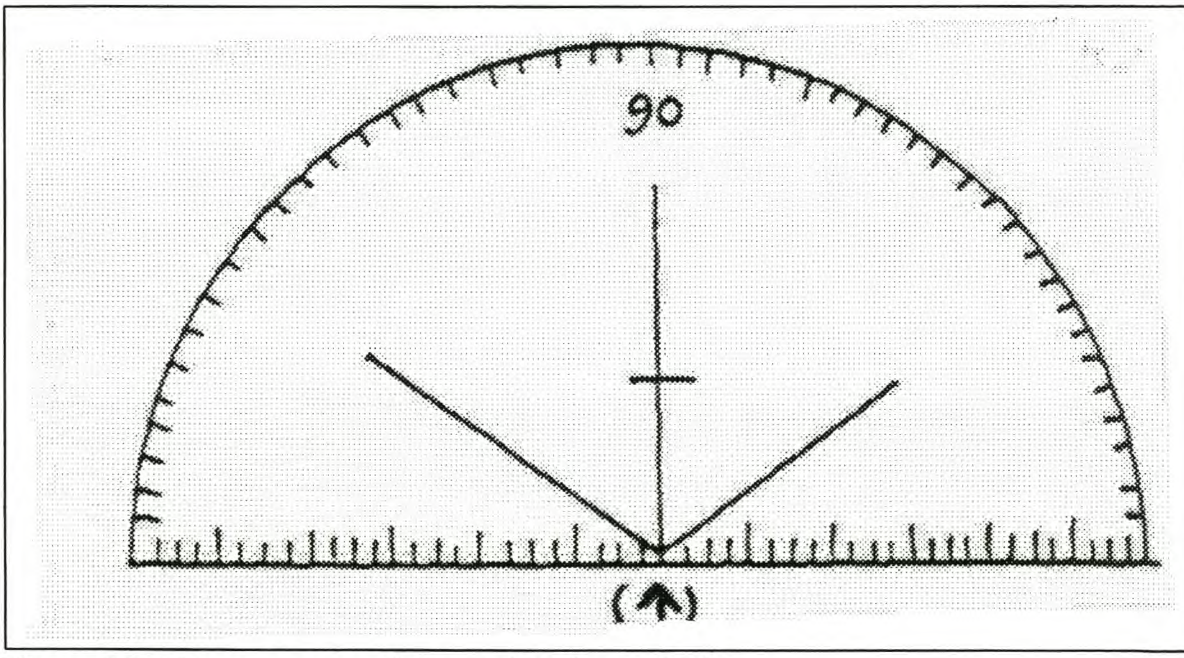


Figure 3.3: The protractor (Johnson & Nelson, 1979).

The Side-Split-Test (Johnson & Nelson, 1979) was also used to measure lateral flexibility. The object of the test is to attempt to get the crotch (i.e. indirectly connected to the flexibility of the hip adductors) as close to the floor as possible by extending the legs outwards (see Figure 3.3). The distance between the inside of the feet was then measured with a Tufmic 12C 20-metre tape-measure. The researcher made sure that the subjects' knees were locked at the moment of measurement and the subjects were allowed to touch the floor with both hands to maintain balance during the test. Subjects were allowed three attempts and the best score/distance was taken as an indication of lateral flexibility.

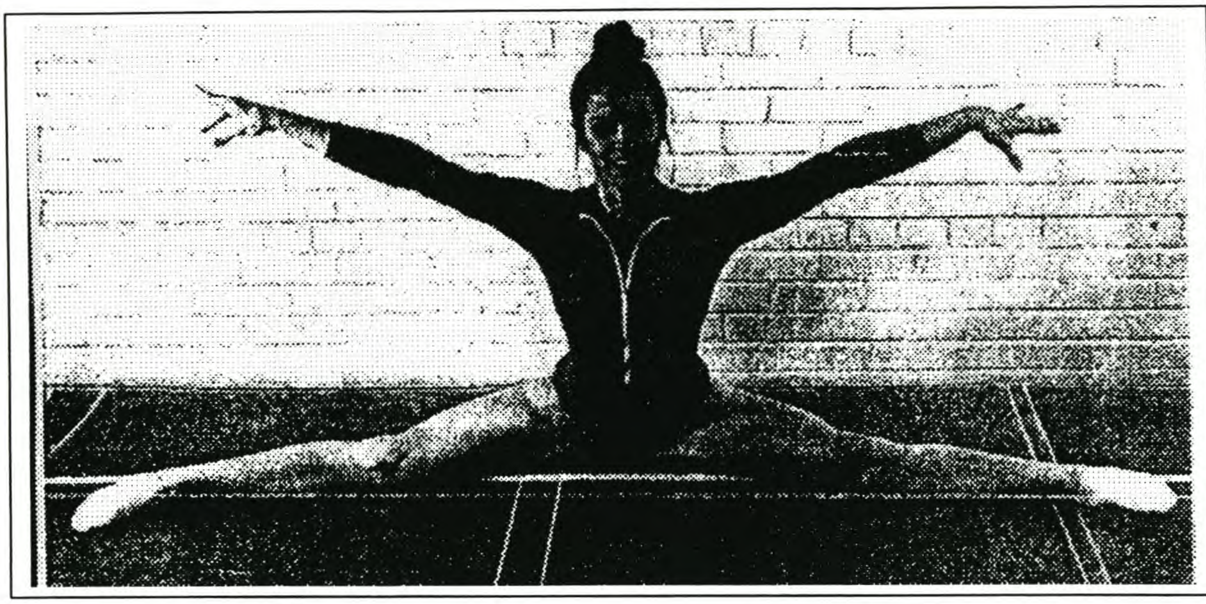


Figure 3.4: The Side-Split-Test (Johnson & Nelson, 1979).

3.7.9 Dynamic balance

The Modified-Bass-Test (Johnson & Nelson, 1979) was used to measure dynamic balance. The Sheffield-Chesterman yardstick was used to measure the floor pattern. The objective was to measure the ability to jump from side-to-side accurately while maintaining balance during and after the movement.

Standing with the right foot on the starting mark (see Figure 3.4 for floor pattern), the subject leaps to the first tape mark with the left foot. The subject tries to hold a steady position on the ball of the left foot for as many seconds as possible to a maximum of five seconds. The subject then leaps to the second marker with the left foot, etc., alternating the feet from marker to marker. The subject should remain on each marker for as many seconds as possible to a maximum of five seconds. The subject's foot must cover the marker completely.

The score for each mark successfully landed on was five points, with five points being additionally awarded if the balance was held for five seconds. A maximum of 100 points could be earned.

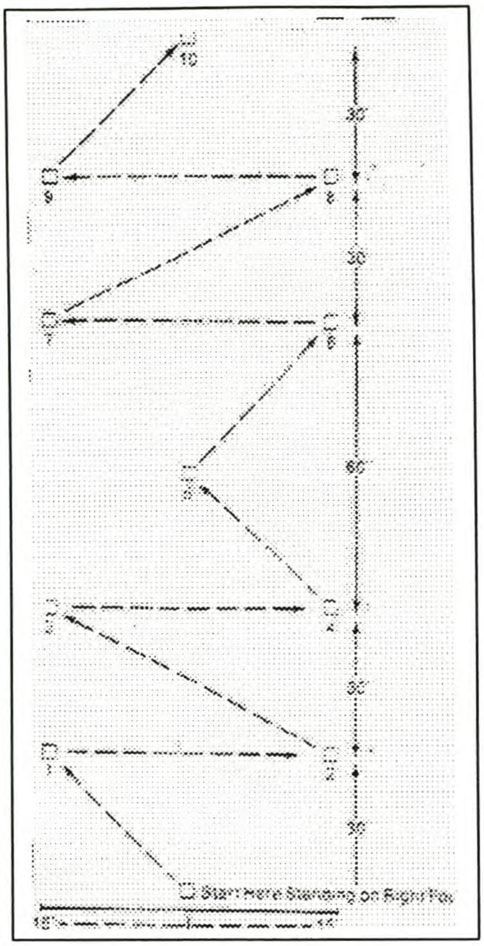


Figure 3.5: The floor pattern for the Modified-Bass-Test (Johnson & Nelson, 1979).

The subjects sacrificed five points for improper landing or if they were not able to balance accurately. Subjects were only allowed one chance.

3.7.10 Isokinetic testing

The KIN-COM 125AP Isokinetic Resistance Dynamometer was used to determine peak concentric and eccentric quadriceps, hamstring, hip abductor and adductor muscle strength.

Testing started with a warm-up consisting of three minutes of fast cycling, followed by stretching of the quadricep, hamstring and calf muscles. While the subject was being positioned in the chair and lever arm length allocated, the subject was informed about the dynamometer, its basic principles as well as what was expected. The protocol (concentric/eccentric testing at 87° range of motion at a speed of 60° per second for the knee) was explained and three warm-up tries were allowed to familiarise the subject with the dynamometer and testing protocol. The subject was given four chances (1^{st} = 50% of maximum force produced, 2^{nd} = 75% of maximum force produced, 3^{rd} = maximum force, 4^{th} = maximum force) with a rest period of 20 seconds between each chance. The subject was able to follow the progress on the computer monitor (visual feedback) at all times and was verbally encouraged with every repetition. The right side was tested first (see Appendix C).

The test was concluded with a cool-down session consisting of 3 minutes of cycling followed by the stretching of the quadricep, hamstring and calf muscles.

The same protocol was followed with the testing of the hip abductors and adductors, except for the range of motion that changed to 30° and the testing speed that changed to 30° per second. Stretches also included the hip abductor and adductor muscles, as well as the gluteus muscles.

To ensure reliability during testing, the researcher ensured that the subject had no pain, was comfortable and was in the correct testing position at all times.

All the measurements obtained were noted on the pre- and post-test data forms (see Appendixes D & E).

3.7.11 Slide board exercise session

The slide boards (Ski-Slide) used in this study was produced by Dalphs & Leisure Products Supply Corporation (Taiwan). Ski-Slide boards are non-adjustable boards. The bumper-to-bumper width is constant at 170 centimetres and the length at 60 centimetres. The product was set up and used according to instructions throughout. Subjects followed the proper exercise training guidelines for the correct and safe use of the slide board as stressed by the slide instructor. The researcher kept the equipment condition at an optimum by wiping and polishing the slide surface before each slide session.

A Sony television set and videocassette recorder were used to display the pre-recorded slide board sessions. A National air conditioner kept the room temperature at a constant 19°C.

On arrival of the subjects at their training session, they were fitted with Cardio Sport heart rate monitors. Figure 3.5 represents the typical display that can be expected during the exercise session.

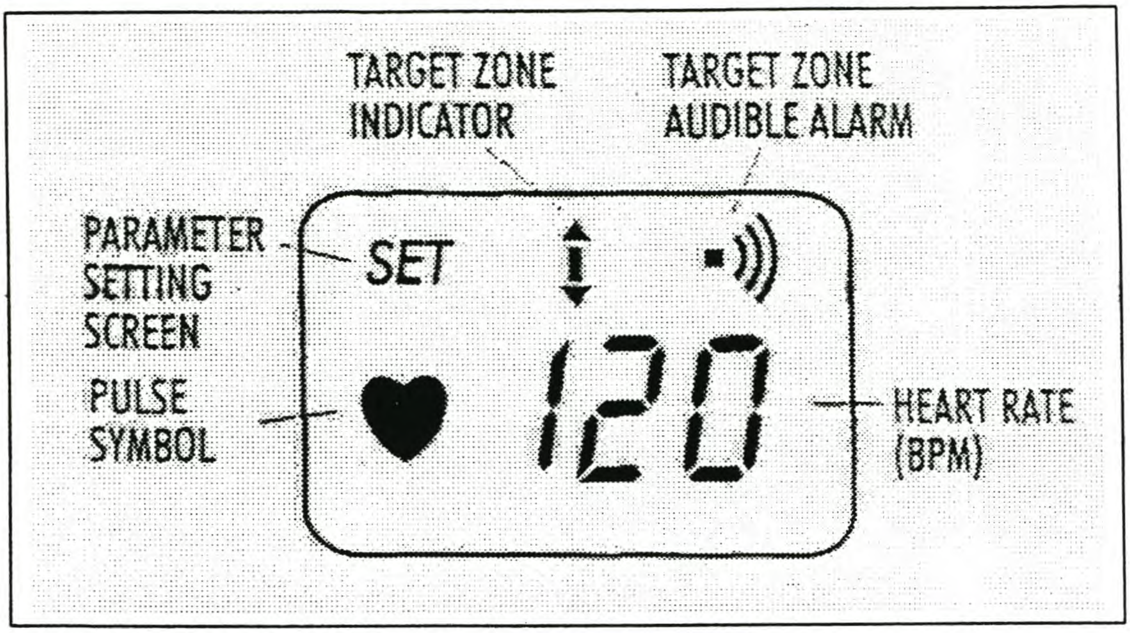


Figure 3.6: Heart rate monitor display

The heart rate monitor consisted of a watch receiver and a transmitter and the specifications can be summarised as follows:

Watch receiver	
Heart rate range	30 to 240 beats per minute (bpm)
Target zones	1
Target zones resolution	1 bpm
High heart rate range	80 to 240 bpm in steps of 1 bpm
Low heart rate range	30 to high minus 5
Minimum target zone width	5 bpm
Heart rate accuracy	= 1 beat per minute
Battery	3 volt Lithium 2032 cell
Battery life	2 years with 60 minutes per day heart rate monitoring
Transmitter	
Emitted frequency	5 kHz = 10%
Battery	3 volt Lithium 2032 cell
Battery life	3 years when used 60 minutes per day
Range	maximum 80 cm to watch receiver

Heart rate was recorded at the beginning and end of the 10-minute warm-up session (as instructed by the video instructor), at the beginning of the 30-minute slide session, every 5-minutes during the slide session and at the beginning and end of the 10-minute cool-down session (see Appendix F).

Each week (for six weeks) the subjects moved to the next level (intensity) of the slide board exercise programme. Each subject had to complete all the sessions (three times a week for six weeks = 18 sessions) within the six weeks in order to complete the intervention programme.

The first three sessions were introductory sessions where the basic principles of slide were mastered before the subjects started with the more advanced movements (higher intensity). At all times the researcher ensured that the subjects executed the movements correctly and that the correct posture was maintained to prevent injury.

3.7.12 Slide board exercise session analysis

See Appedix G. for the exercise session analysis.

3.8 DATA ANALYSIS

The Statistical Package for the Social Sciences (SPSS), Version 8.0 for Windows was used to interpret the pre- and post-test measurements.

Due to the size of the groups, non-parametric methods were used to draw inferences from the data. For the descriptive data (minimum, maximum, mean and standard deviation), the Wilcoxon Matched-Pairs Signed-Ranks Test was used to compare the subjects within each group.

The Kruskal-Wallis One-way Analysis of Variance was used to draw comparisons between the groups. The Mann-Whitney Test, a post-hoc test, was used to identify the groups.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

A total of 29 subjects volunteered to participate in the six-week lateral movement training project. Six subjects did not complete the six-week intervention programme for the following reasons:

- Two subjects developed lower back pain – one having injured her back during a netball match, the other while participating in recreational sport.
- One subject developed patella tendinitis.
- One subject suffered a sprained ankle while participating in regional trails.
- One subject developed ilio-tibial band syndrome in the left knee with accompanying chondromalacia.
- One subject developed inflammation of the left groin (insertion of the adductor muscles).

Five of those who did not complete the intervention programme were from group 1 (the club netball players), while the remaining subject was from group 2 (the residence netball players).

The injuries suffered by the subjects of group 1 may be explained by the fact that they participated in a plyometric exercise programme done on a hard concrete floor, instead of one that gives away on impact, an example being a gymnastic floor. They also suffered from burnout and over-training due to the very intense exercise programme. This aggravated old injuries of the previous season.

Twenty-three subjects completed the pre- and post-test, while the 15 subjects of groups 1 and 2 completed the six-week lateral movement training intervention programme.

This chapter will be structured under the following headings:

4.2 Results (descriptive results obtained from all 23 subjects)

4.3 Discussion according to anthropometric data/results
motor performance data
physical performance data
physiological data

4.2 RESULTS

The descriptive data of groups 1, 2 and 3 were recorded on data sheets during the pre- and post-tests (Appendixes D & E). The heart rates of groups 1 and 2 were recorded prior to and during every exercise session and noted on the heart rate report form (Appendix F).

Anthropometric data include mass, body fat percentage and thigh and calf circumferences. Motor performance data include the variables of lateral agility and dynamic balance. Physical fitness data include lateral flexibility and the strength of the quadriceps, hamstring, abductor and adductor muscles.

The raw data (pre- and post-test data) for groups 1, 2 and 3 are displayed below in Tables 4.1, 4.2 and 4.3. The minimum, maximum, mean and standard deviation values are displayed.

Table 4.1: Raw data of group 1.

	N	Minimum	Maximum	Mean	Std. Deviation
PRETHIR	5	51.70	58.60	54.9000	2.6711
POSTTHIR	5	49.90	57.00	54.3800	2.8048
PRETHIL	5	50.80	58.20	54.4600	2.7437
POSTTHIL	5	50.00	58.50	55.5400	3.2370
PRECALFR	5	36.50	39.60	38.1600	1.1675
POSCALFR	5	36.20	38.80	37.6200	.9338
PRECALFL	5	36.20	39.50	38.1000	1.2104
POSCALFL	5	35.80	39.00	37.7400	1.2422
PREFATPE	5	16.40	27.80	20.8400	4.5059
POSFATPE	5	13.90	21.20	16.6000	2.7468
PREAGIL	5	7.00	8.00	7.6600	.4775
POSTAGIL	5	7.30	8.10	7.7800	.4382
PREPROTR	5	80.00	110.00	94.8000	12.3976
POSPROTR	5	98.00	123.00	107.6000	11.5456
PREPRTRC	5	73.00	116.00	97.4000	16.0717
POSPRTRC	5	101.00	112.00	106.8000	4.3243
PRESSST	5	1.49	1.77	1.6280	.1088
POSTSST	5	1.51	1.77	1.6440	.1205
PREBALNC	5	80.00	95.00	89.0000	6.5192
POSBALNC	5	90.00	100.00	94.0000	4.1833
PRERQCON	5	124.00	205.00	175.2000	33.1693
POSRQCON	5	141.00	210.00	174.6000	31.0854
PRERQECC	5	177.00	297.00	255.6000	48.6292
POSRQECC	5	194.00	304.00	247.4000	40.5068
PRERHCON	5	65.00	101.00	82.4000	17.0382
POSRHCON	5	75.00	102.00	88.2000	11.5412
PRERHECC	5	111.00	174.00	131.4000	26.3306
POSRHECC	5	103.00	166.00	141.6000	27.0795
PRELQCON	5	105.00	182.00	151.4000	31.5246
POSLQCON	5	120.00	190.00	158.8000	28.5430
PRELQECC	5	135.00	258.00	212.6000	47.6372
POSLQECC	5	145.00	261.00	208.6000	43.3970
PRELHCON	5	73.00	128.00	94.0000	22.3271
POSLHCON	5	80.00	124.00	103.0000	18.0555
PRELHECC	5	91.00	196.00	135.2000	39.2645
POSLHECC	5	88.00	149.00	128.0000	23.6114
PRRABDCO	5	111.00	154.00	136.4000	16.7869
PORABDCO	5	108.00	154.00	131.2000	17.3407
PRRABDEC	5	136.00	183.00	160.4000	20.3298
PORABDEC	5	138.00	181.00	161.0000	19.2224
PRRADDCO	5	123.00	159.00	145.6000	16.5167
PORADDCO	5	130.00	174.00	156.6000	16.3799
PRRADDEC	5	154.00	208.00	182.6000	21.3729
PORADDEC	5	181.00	219.00	204.0000	14.5258
PRLABDCO	5	108.00	162.00	129.6000	21.6056
PORLABDC	5	121.00	168.00	140.8000	17.5983
PRLABDEC	5	107.00	192.00	149.4000	40.5191

Table 4.2: Raw data of group 2.

	N	Minimum	Maximum	Mean	Std. Deviation
PRETHIR	9	46.80	61.50	52.9889	4.0247
POSTTHIR	9	47.00	62.50	53.3667	4.3526
PRETHIL	9	46.50	62.00	53.4111	4.2540
POSTTHIL	9	47.60	62.40	53.8111	4.1417
PRECALFR	9	32.50	39.00	35.6556	1.7343
POSCALFR	9	32.20	39.00	35.6444	1.9660
PRECALFL	9	33.00	39.80	35.9778	1.7662
POSCALFL	9	33.40	39.80	35.9889	1.8550
PREFATPE	9	15.40	25.70	21.3889	3.2452
POSFATPE	9	12.90	24.90	19.4778	3.4073
PREAGIL	9	6.30	7.30	7.0667	.3082
POSTAGIL	9	7.10	8.00	7.3556	.3712
PREPROTR	9	77.00	143.00	108.8889	19.0620
POSPROTR	9	96.00	135.00	113.2222	11.7450
PREPRTRC	9	84.00	137.00	108.7778	16.3843
POSPRTRC	9	96.00	133.00	115.3333	11.1018
PRESST	9	1.46	1.74	1.6089	9.714E-02
POSTSST	9	1.46	1.80	1.6278	.1151
PREBALNC	9	50.00	90.00	72.7778	13.9443
POSBALNC	9	85.00	100.00	92.7778	5.0690
PRERQCON	9	99.00	184.00	146.3333	26.7815
POSRQCON	9	121.00	188.00	143.6667	21.9146
PRERQECC	9	119.00	233.00	190.2222	34.4448
POSRQECC	9	142.00	230.00	186.0000	31.0524
PRERHCON	9	56.00	114.00	74.5556	16.6817
POSRHCON	9	46.00	115.00	73.1111	19.8081
PRERHECC	9	66.00	133.00	106.3333	21.8918
POSRHECC	9	68.00	132.00	101.0000	21.1365
PRELQCON	9	107.00	157.00	136.1111	17.3237
POSLQCON	9	107.00	174.00	137.0000	20.4573
PRELQECC	9	152.00	221.00	179.5556	25.2642
POSLQECC	9	151.00	206.00	175.6667	23.6220
PRELHCON	9	55.00	114.00	72.3333	17.5428
POSLHCON	9	52.00	91.00	68.6667	13.8834
PRELHECC	9	82.00	141.00	105.6667	21.5754
POSLHECC	9	72.00	153.00	101.0000	27.3724
PRRABDCO	9	86.00	157.00	106.6667	23.4414
PORABDCO	9	78.00	165.00	112.6667	26.8282
PRRABDEC	9	102.00	170.00	125.1111	20.2512
PORABDEC	9	95.00	138.00	123.6667	14.2390
PRRADDCO	9	97.00	152.00	118.8889	19.4579
PORADDCO	9	99.00	217.00	134.1111	33.0811
PRRADDEC	9	112.00	180.00	144.1111	23.1864
PORADDEC	9	124.00	176.00	153.3333	17.5926
PRLABDCO	9	76.00	114.00	98.7778	13.8454
PORLABDC	9	73.00	158.00	101.1111	25.1617
PRLABDEC	9	99.00	149.00	121.1111	15.3984
POLABDEC	9	96.00	131.00	114.5556	12.6007
PRLADDCO	9	89.00	137.00	115.0000	15.6045

Table 4.3: Raw data of group 3.

	N	Minimum	Maximum	Mean	Std. Deviation
PRETHIR	9	38.50	59.90	50.6778	6.5574
POSTTHIR	9	45.30	58.80	51.3556	4.7260
PRETHIL	9	38.60	59.60	50.3444	6.3099
POSTTHIL	9	46.00	58.30	51.5222	4.3427
PRECALFR	9	30.40	41.40	35.8111	3.7883
POSCALFR	9	29.50	40.80	35.4556	3.7740
PRECALFL	9	30.80	41.10	35.8222	3.5024
POSCALFL	9	30.50	40.60	35.6333	3.4792
PREFATPE	9	14.30	26.30	18.6778	4.6094
POSFATPE	9	13.50	23.90	16.5778	3.1031
PREAGIL	9	6.30	8.00	7.4222	.7429
POSTAGIL	9	6.30	8.20	7.3778	.6340
PREPROTR	9	95.00	124.00	105.7778	9.1485
POSPROTR	9	98.00	120.00	109.7778	7.8705
PREPRTRC	9	95.00	123.00	107.4444	9.7225
POSPRTRC	9	89.00	120.00	111.2222	10.2320
PRESST	9	1.45	1.93	1.6561	.1681
POSTSST	9	1.50	1.88	1.6711	.1412
PREBALNC	9	65.00	100.00	80.5556	10.1379
POSBALNC	9	80.00	100.00	89.4444	7.2648
PRERQCON	9	104.00	247.00	162.3333	47.5631
POSRQCON	9	103.00	222.00	156.6667	42.9447
PRERQECC	9	139.00	349.00	222.5556	69.9395
POSRQECC	9	139.00	308.00	209.6667	50.2145
PRERHCON	9	44.00	128.00	76.6667	26.2536
POSRHCON	9	56.00	112.00	80.7778	18.4917
PRERHECC	9	90.00	187.00	121.6667	28.8401
POSRHECC	9	76.00	184.00	115.3333	30.6635
PRELQCON	9	100.00	243.00	163.6667	47.5868
POSLQCON	9	111.00	233.00	150.3333	40.9145
PRELQECC	9	157.00	332.00	222.1111	59.5240
POSLQECC	9	146.00	346.00	213.7778	57.0828
PRELHCON	9	47.00	110.00	76.7778	20.4376
POSLHCON	9	61.00	112.00	83.8889	18.4150
PRELHECC	9	84.00	173.00	116.3333	26.0768
POSLHECC	9	92.00	181.00	124.5556	28.6274
PRRABDCO	9	92.00	170.00	131.8889	31.1667
PORABDCO	9	89.00	210.00	126.2222	40.2547
PRRABDEC	9	108.00	204.00	145.8889	37.4681
PORABDEC	9	101.00	179.00	135.6667	23.9531
PRRADDCO	9	74.00	204.00	129.7778	42.6491
PORADDCO	9	79.00	186.00	121.7778	32.4337
PRRADDEC	9	96.00	243.00	161.4444	50.6634
PORADDEC	9	117.00	216.00	157.8889	33.9354
PRLABDCO	9	85.00	167.00	112.6667	30.9556
PORLABDC	9	79.00	169.00	111.2222	29.1238
PRLABDEC	9	95.00	226.00	141.8889	47.2426

4.3 DISCUSSION

4.3.1 ANTHROPOMETRIC RESULTS

MASS

The mass of group 1 (the club netball players) shows a downward tendency (Figure 4.1). In other words, the post-test measurement showed a decline in mass for everyone, except for subject 4 of group 1 whose mass remained constant.

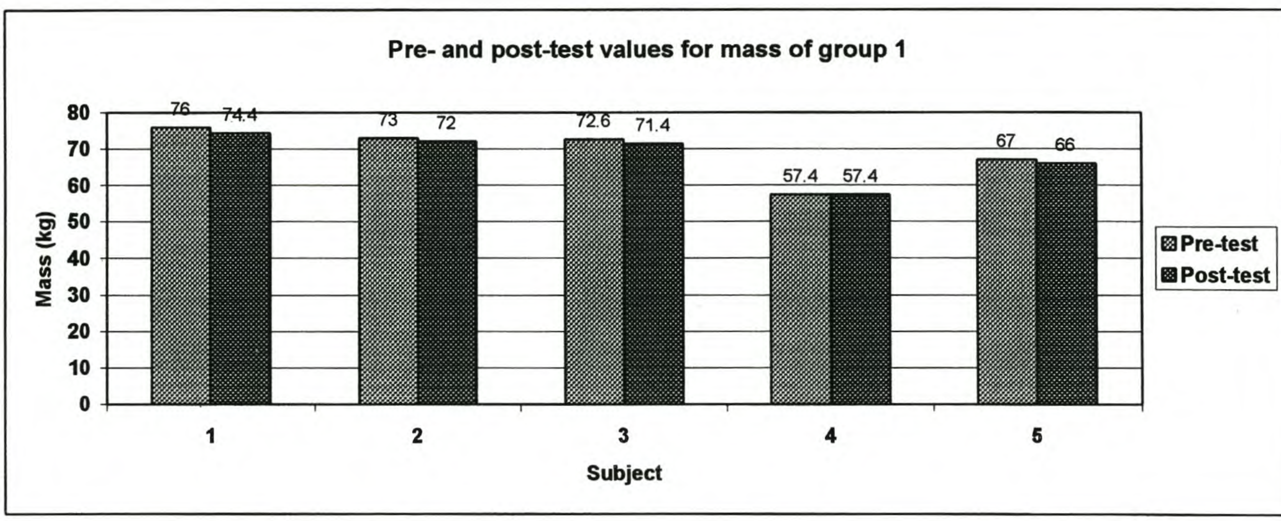


Figure 4.1: Pre- and post-test values for mass of group 1.

Regarding group 2 (the residence netball players), Figure 4.2 indicates that 6 subjects showed a decrease in mass between the pre-test and post-test period. Subjects 3, 5 and 6 showed an increase in mass in this period. This could be due to an increase in muscle mass as a result of the six-week lateral movement training programme.

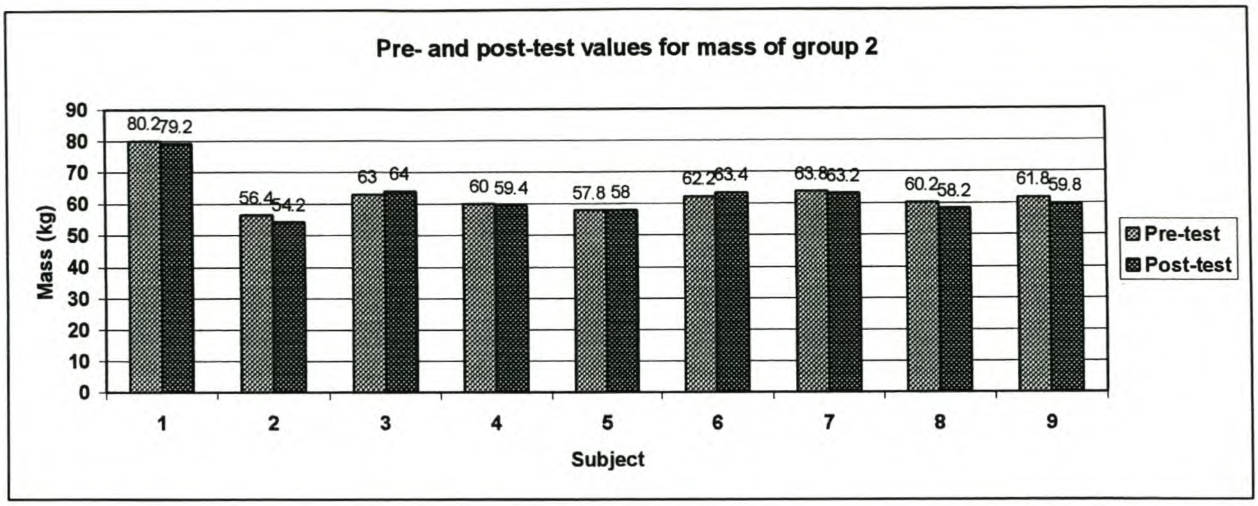


Figure 4.2: Pre- and post-test values for mass of group 2.

Figure 4.3 indicates that the mass of group 3 (the control group) remained basically constant, except for subjects 2 and 3 who showed an increase in mass. These two subjects were from the netball club and the increase in mass could have been due to an increase in muscle mass as a result of the club's intensive training programme.

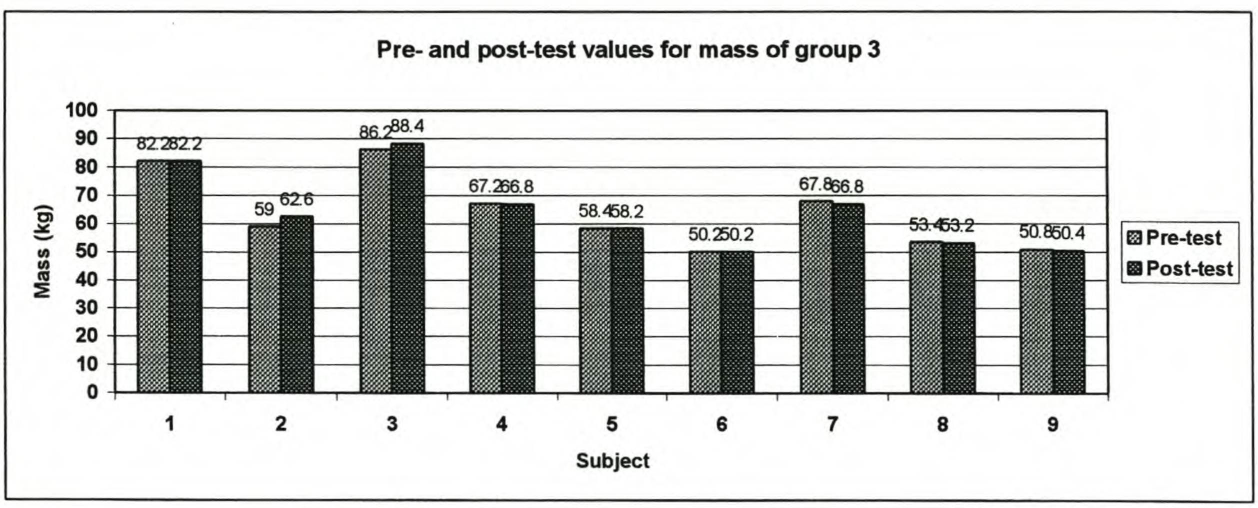


Figure 4.3: Pre- and post-test values for mass of group 3.

BODY FAT PERCENTAGE

Looking at the histogram presentation of the three groups in Figures 4.4, 4.5 and 4.6, a general decrease in body fat percentage is notable. Group 1 shows a mean decrease of 4.24% in body fat percentage during the six-week lateral movement training period, thus indicating a significant difference ($p < 0.05$) between pre- and post-test.

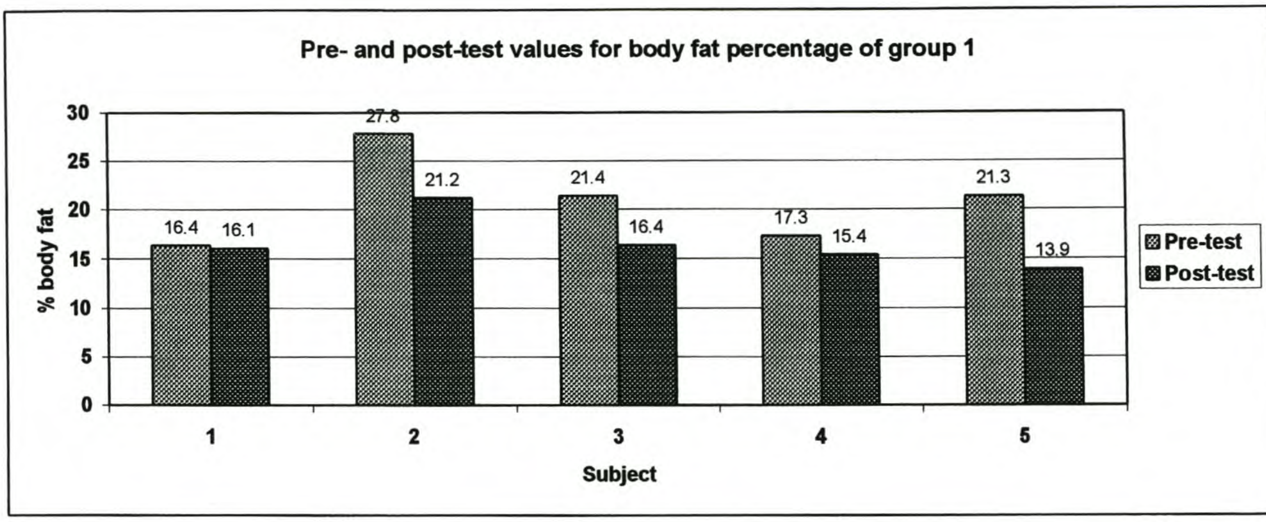


Figure 4.4: Pre- and post-test values for body fat percentage of group 1

Group 2 shows a mean decrease in body fat percentage of 1.91% in the intervention period, indicating a significant difference ($p < 0.05$) between the pre- and post-test.

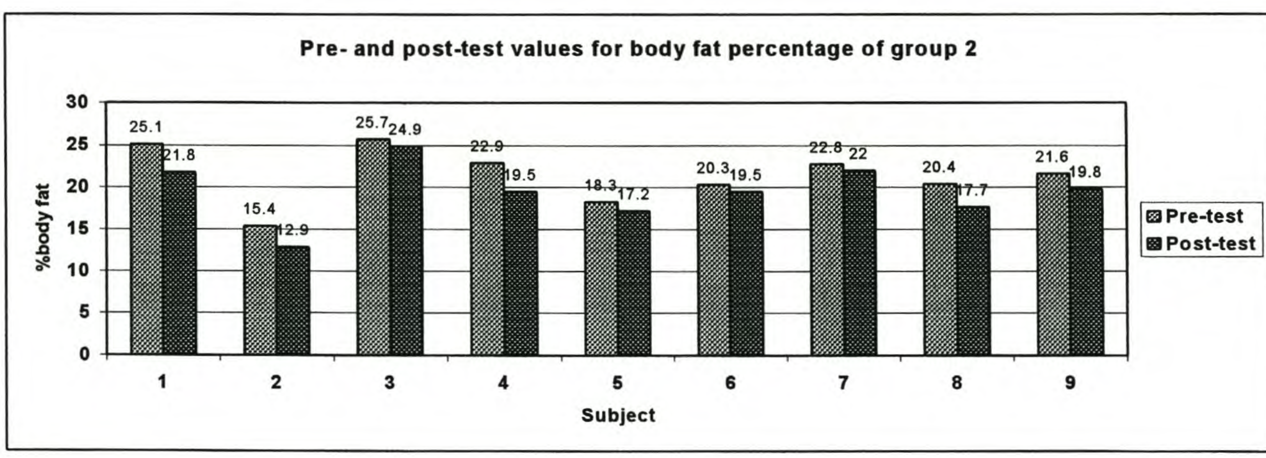


Figure 4.5: Pre- and post-test values for body fat percentage of group 2.

It is clear that the decrease in body fat percentage is greater for group 1 (club netball players) than for group 2 (residence netball players). This may be due to the more structured and intense exercise programme of the netball club, which may have contributed to the greater loss of body fat percentage.

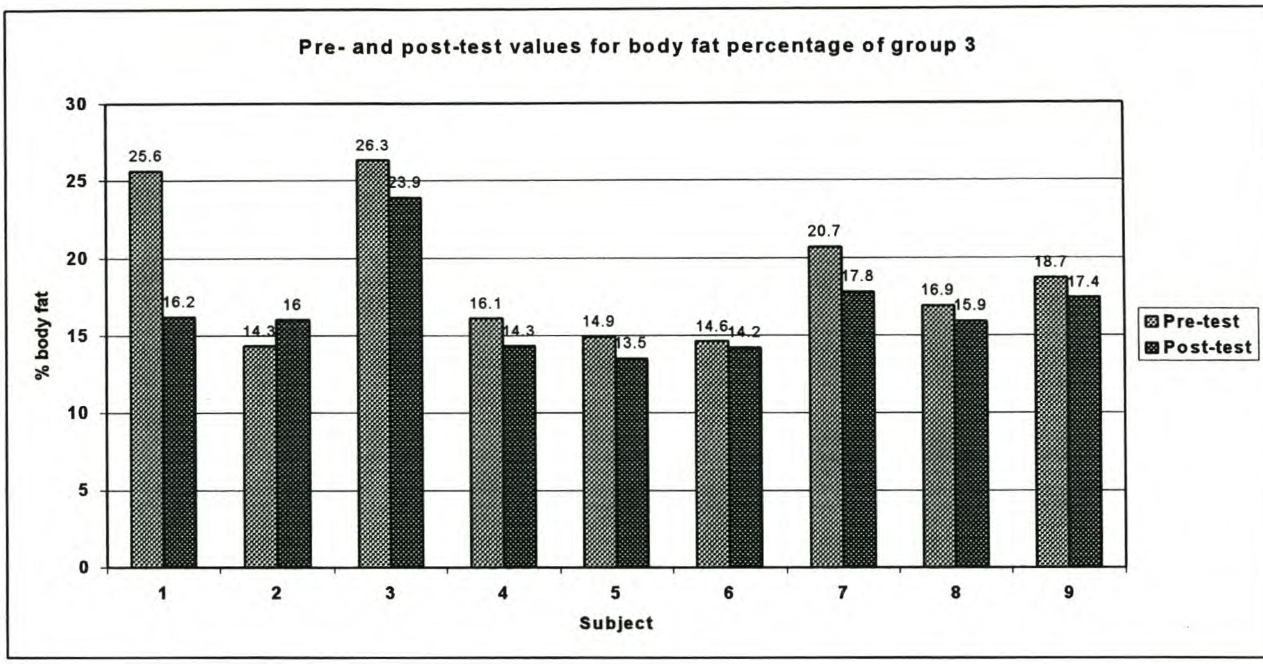


Figure 4.6: Pre- and post-test values for body fat percentage of group 3.

Group 3 (control group) shows a mean decrease in body fat percentage of 2.1%, thus a significant difference ($p < 0.05$) between pre- and post-test. Figure 4.6 shows that subject 1 experienced a significant decrease of 9.4% in fat percentage. She was from the netball club, indicating that the club's exercise programme itself could have had a substantial added influence on the body fat percentage of its players.

The literature states that slide board training is an excellent aerobic exercise that burns fat when subjects exercise at a heart rate of 60% - 90% of maximum heart rate (ACSM, 1995:158; Williford, 1994:35). Ideally the six-week lateral movement training programme should therefore lead to a decrease in body fat percentage. The statistical analysis shows just such a decrease.

It is concluded that although the exercise programmes of the netball club and residence could have played a role in the decrease of body fat percentage, the six-week lateral movement training programme lead to an overall significant decrease in body fat percentage. This also indicates that the programme contained an appropriate aerobic component (discussed later in this chapter).

THIGH CIRCUMFERENCE

Ideally the thigh girth measurements should show a slight increase after the intervention period. Although the six-week training programme focused on the hip abductor and adductor muscles, the quadriceps and hamstring muscles were also utilised, but mostly in an isometrically contracted state.

The statistical analysis does not show any significant differences in thigh circumferences when comparing the subjects within each group, or between the groups.

One possible explanation for the lack of significant differences could be that during sliding the quadriceps and hamstring muscles are mostly utilised in an isometric state. Since the literature seems to conclude that eccentric and concentric muscle contractions are needed for muscle hypertrophy (De Vries & Housh, 1994:427), this lack of sufficient concentric and eccentric contractions of the quadriceps and hamstring muscles could explain the lack of significant differences in thigh circumferences. It seems, therefore, that the six-week lateral movement training programme lead to the toning of the thigh muscles (a better shape) and not the enlargement (hypertrophy) thereof. This assumption is made on the basis of personal feedback by the subjects regarding the general shape of their muscles.

CALF CIRCUMFERENCE

The literature states that calf muscles are also utilised when slide boarding (Diener, 1994:27). When looking at the different phases of slide boarding (the push-off phase, the sliding phase and the contact-recovery phase) it is apparent that the calf muscles contract concentrically during the push-off phase, isometrically during the sliding/glide phase and eccentrically during the contact-recovery phase. The exercise therefore does contain the criteria (i.e. concentric and eccentric muscle contractions) needed for muscle hypertrophy.

The statistical analysis does not show any significant differences in calf circumferences when the subjects within each group are compared with one another, or when groups are compared.

A possible explanation for the above-mentioned lack of significant differences in calf circumferences, could be that although the calf muscles worked concentrically and eccentrically when slide boarding, the intensity load may not have been enough to elicit an increase in calf circumferences.

There was a decrease in the mean calf circumferences of groups 1 and 2, which indicates that the six-week slide board training programme lead to the toning of calf muscles, rather than to their hypertrophy. The above mentioned findings show that lateral movement training is an excellent exercise for the toning of calf muscles. The latter assumption is once again made on the basis of personal feedback by the subjects.

The data analysis thus far indicates that a six-week lateral movement training programme elicits the toning of calf and thigh muscles and a decrease in body fat percentage and body mass.

4.3.2 MOTOR PERFORMANCE RESULTS

LATERAL AGILITY

The Wilcoxon Signed Ranks Test was used to compare the subjects. Within each group's pre- and post-test measurements, a significant difference ($p < 0.05$) in lateral agility was found within group 2 (Figure 4.7).

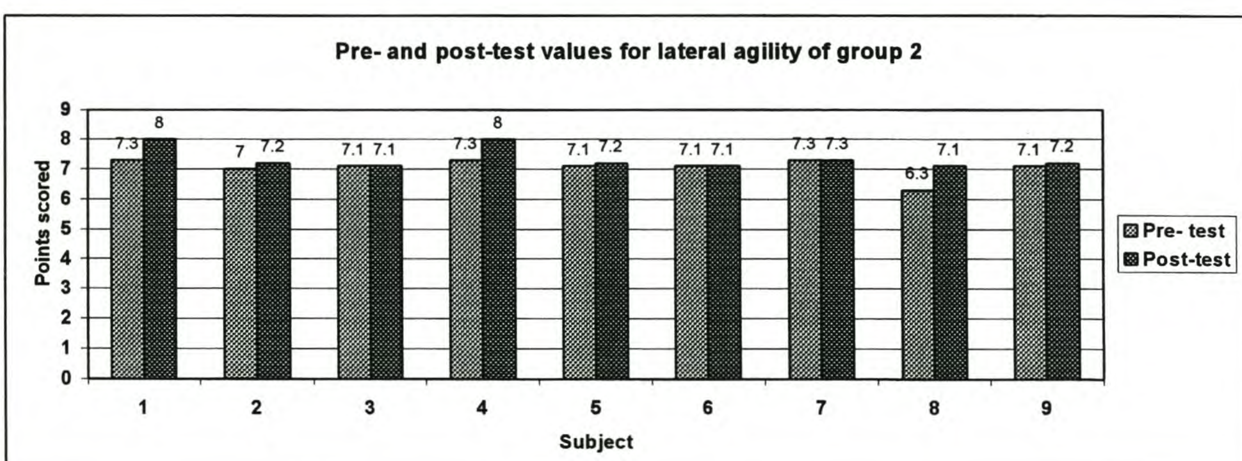


Figure 4.7: Pre- and post-test values for lateral agility of group 2.

In Figure 4.7 most of the subjects (n=6) in group 2 (representing the residence netball players) show an increase in the distance travelled laterally in the 10 seconds allowed (Side-Step-Test). Subjects 3, 6 and 7 show similar results for lateral agility in the pre- and post-test.

The exercise programme of group 2 was not as structured and intense as that of the netball players from the club (group 1). Figure 4.8 further shows that the initial lateral agility of group 1 was much higher than that of group 2. The margin for improvement for group 2 was much greater than that of group 1 and the increase in lateral agility can be ascribed to this fact.

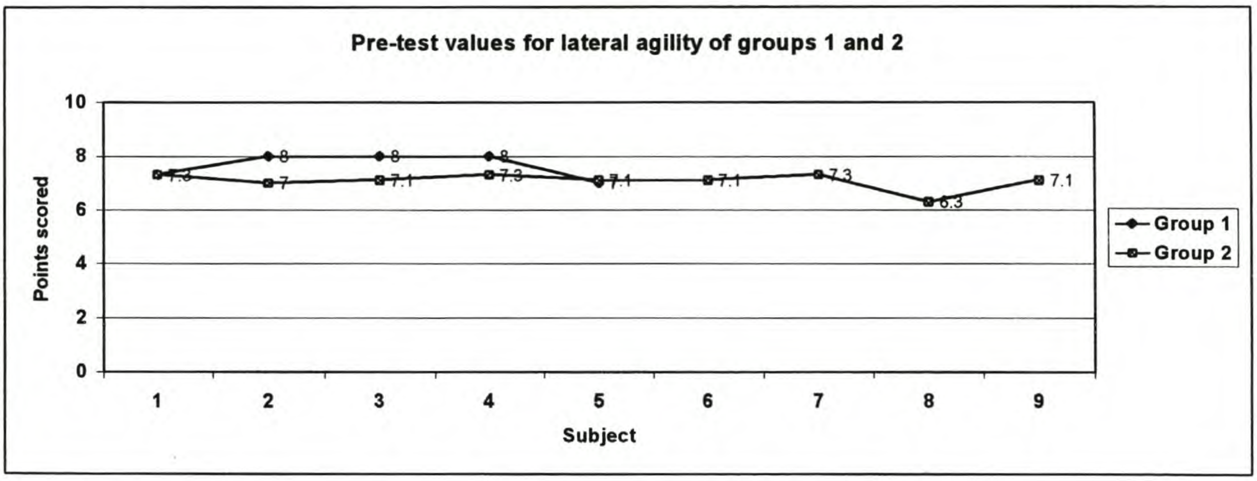


Figure 4.8: Pre-test values for lateral agility of groups 1 and 2.

It can thus be concluded that a six-week lateral movement training programme can lead to better lateral agility for subjects with weaker lateral agility abilities. The programme can also be used for the maintenance of the high levels of lateral agility already achieved by the 1st and 2nd team club netball players.

DYNAMIC BALANCE

The Wilcoxon Signed Ranks Test disclosed significant differences ($p < 0.05$) in the dynamic balance pre- and post-test values within group 2. Descriptive statistics shows a difference in the mean dynamic balance values of 20 points, indicating an increase of 20%. Figure 4.9 shows that all the subjects of group 2 reported an increase in points scored during the Modified-Bass-Test. Subjects 2, 6 and 8 showed increases of 30% - 45%.

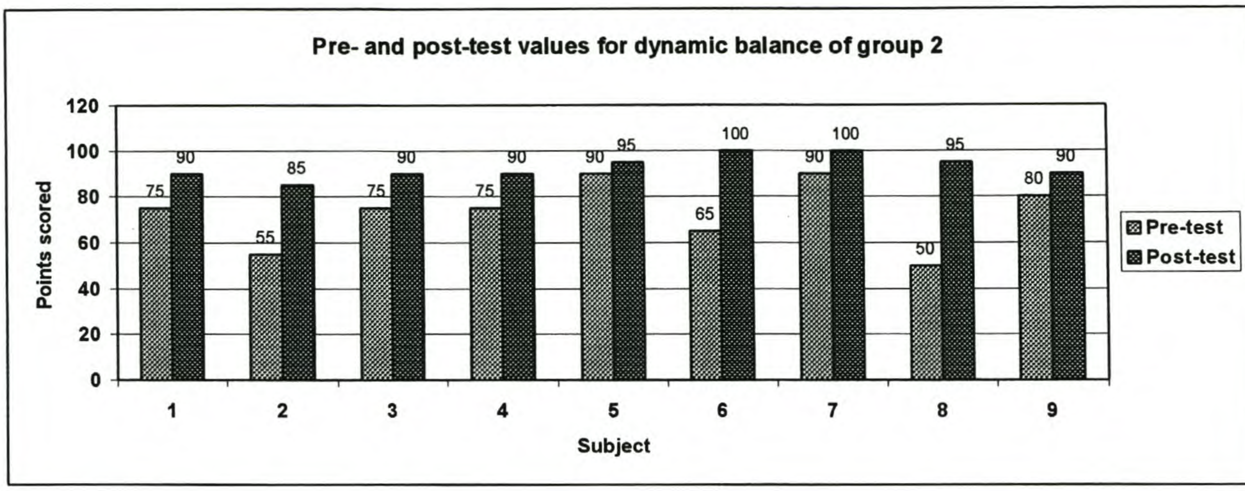


Figure 4.9: Pre-and post-test values for dynamic balance of group 2.

No significant differences were found between the pre- and post-test values of groups 1 and 3.

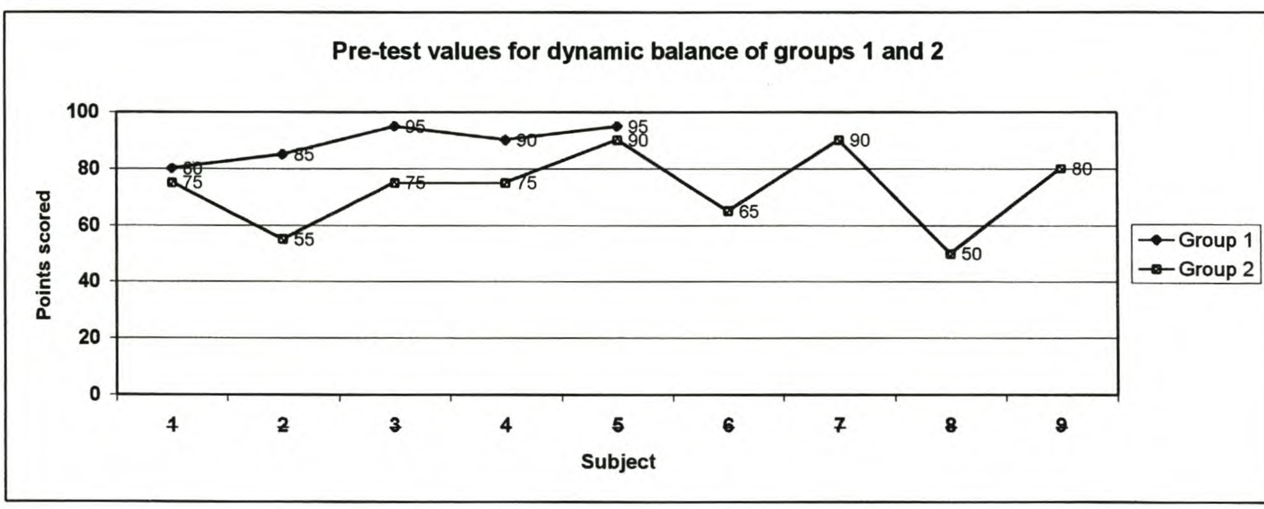


Figure 4.10: Pre-test values for dynamic balance of groups 1 and 2.

Figure 4.10 indicates that regarding dynamic balance, the pre-test values of group 1 were already on a much higher level than that of group 2. Thus the margin for improvement of group 2 was much greater than that of group 1. This once again indicates that a six-week lateral movement training programme increases the dynamic balance abilities of subjects with only moderate levels of balance.

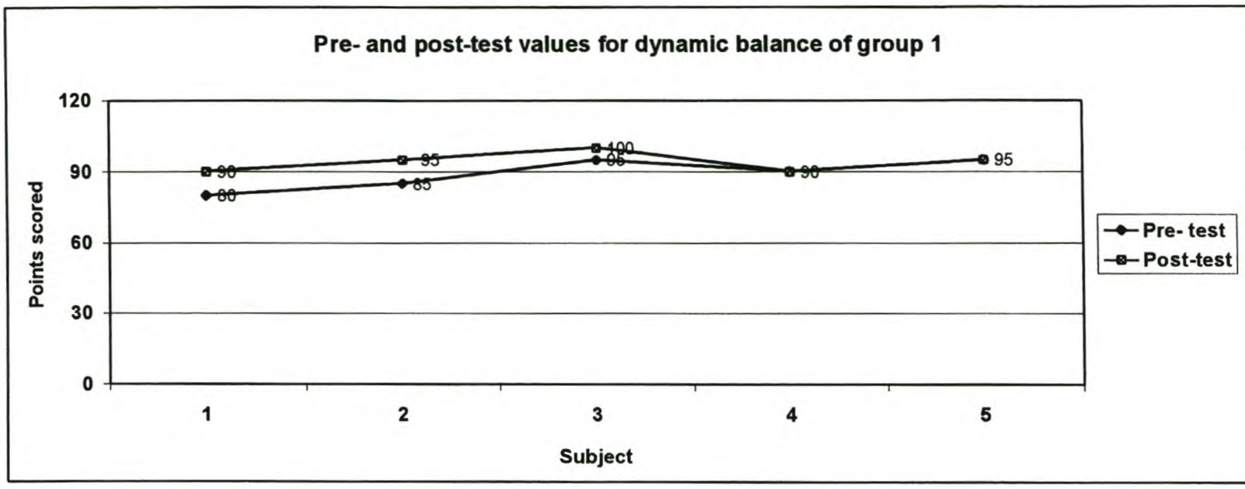


Figure 4.11: Pre- and post-test values for dynamic balance of group 1.

Figure 4.11 shows that a six-week lateral movement training programme can be utilised for the maintenance of high levels of dynamic balance already obtained by the 1st and 2nd team club netball players. The level previously obtained may be the reason for the slide boarding programme not eliciting a significant training response.

4.3.3 PHYSICAL FITNESS RESULTS

LATERAL FLEXIBILITY

None of the three groups showed any significant increases in lateral flexibility.

Flexibility is only increased if the exercise programme consists of a stretching programme focussing on the muscles involved (Peterson & Renström, 1994:95). The statistics thus indicates that the warm-up and cool-down sessions before and after each exercise session did not elicit a high enough training response with regards to lateral agility. This is most probably due to the absence of a substantial stretching regime.

MUSCLE STRENGTH

The concentric and eccentric muscle strength of the quadriceps, hamstring, hip abductor and hip adductor muscles was measured with the Kin-Com 125AP Isokinetic Resistance Dynamometer.

The Wilcoxon-Signed-Ranks-Test disclosed significant differences ($p < 0.05$) in pre- and post-test values of the following variables in group 1 (1st and 2nd team club netball players): right concentric adductor, right eccentric adductor and left concentric abductor hip muscles.

Figure 4.12 illustrates the pre- and post-test values of the concentric right hip adductor muscle strength. All the subjects of group 1 show increases in strength, especially subject 2 who reported an increase of 22 Nm/sec. Descriptive statistics indicates a mean increase in muscle strength of 11 Nm/sec for group 1.

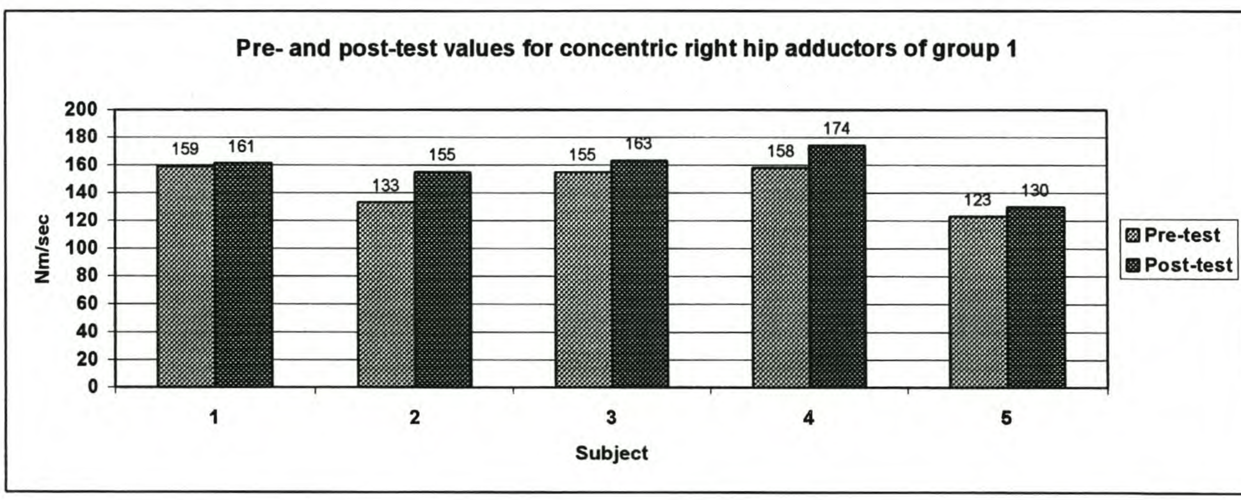


Figure 4.12: Pre- and post-test values for concentric right hip adductors of group 1.

Figure 4.13 illustrates the pre- and post-test values of the eccentric right hip adductor muscle strength. All five subjects of group 1 once again recorded an increase in muscle strength. Subject 2 recorded the greatest increase of 57 Nm/sec. Descriptive statistics indicates a mean increase in muscle strength of 21.4 Nm/sec for group 1.

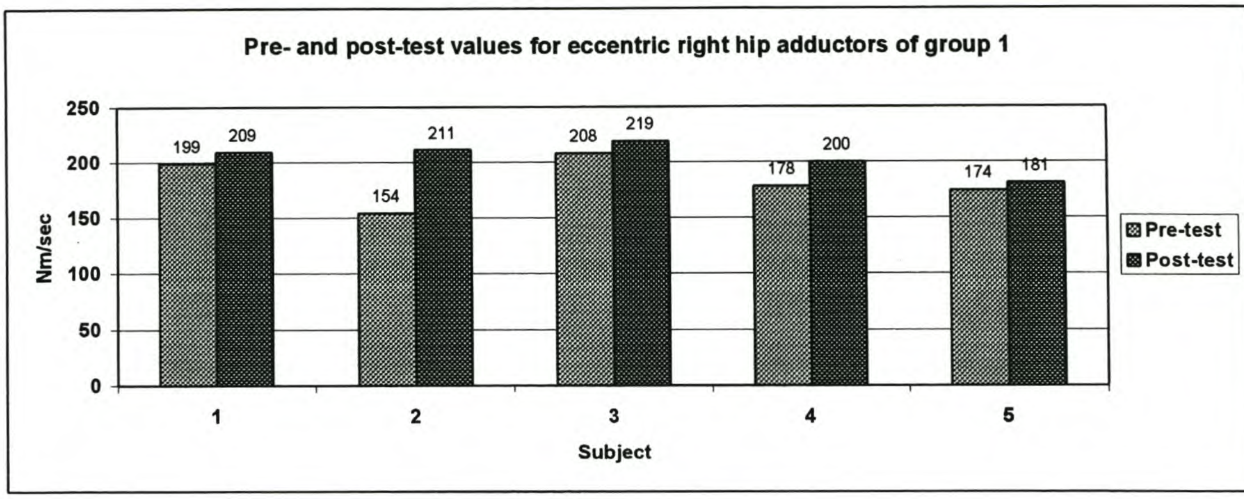


Figure 4.13: Pre- and post-test values for eccentric right hip adductors of group 1.

Figure 4.14 indicates the differences between the pre- and post-test values of the concentric right hip abductors of group 1. All the subjects in group 1 recorded increases in muscle strength, especially subjects 4 and 5. Descriptive statistics indicates a mean increase in muscle strength of 11.2 Nm/sec.

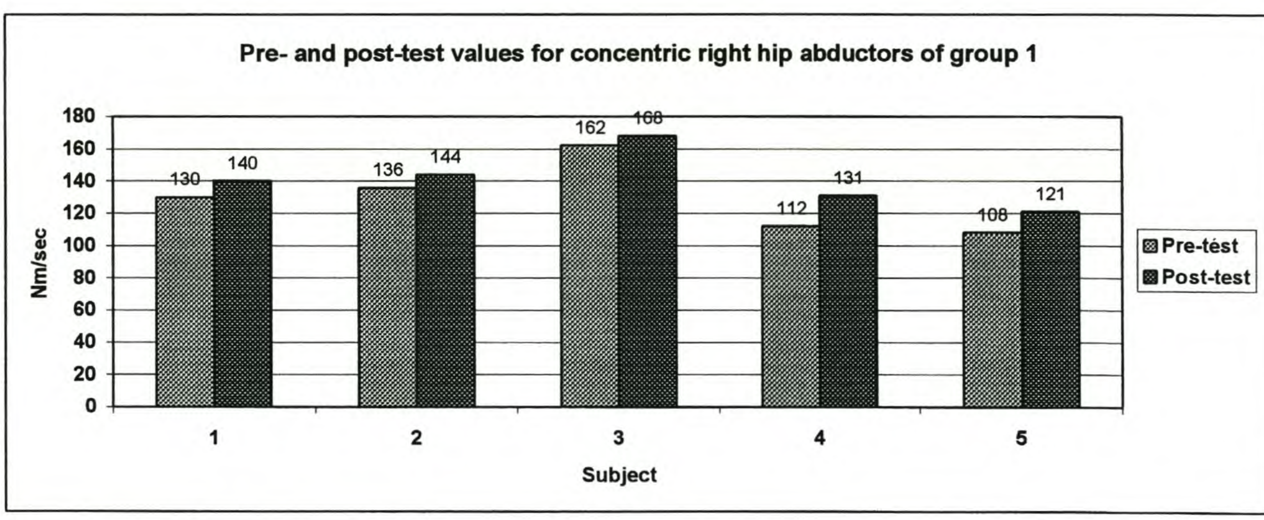


Figure 4.14: Pre- and post-test values for concentric right hip abductors of group 1.

Table 4.4: A summary of the mean increases in muscle strength of group 1.

Group	Muscle	Mean increase
1	R con hip add	11 Nm/sec
1	R ecc hip add	21.4 Nm/sec
1	R con hip abd	11.2 Nm/sec

The literature states that a lateral movement training programme focuses mainly on the hip abductors and adductors, since these muscles are the primary movers during all three phases of the slide (Reese & Lavery, 1991:23). The hip adductors especially show a greater increase in muscle strength (21.4 Nm/sec), because these muscles are not usually targeted for training during normal netball exercise programmes. The statistics also indicates that the six-week lateral movement training programme consisted of a sufficient workload to elicit a training response in these muscles.

As shown by the statistics, the subjects of group 2 recorded an increase in abductor and adductor muscle pre- and post-test strength, but the increases were not significant on the $p < 0.05$ scale.

The post-hoc Mann-Whitney Test was used to draw comparisons between the three groups. The results indicate a significant difference ($p < 0.05$) between group 1 and group 2 regarding post-test left concentric hamstring muscle strength (Figure 4.15). It is clear that group 1 shows a higher level of muscle strength for the same variable than group 2 does.

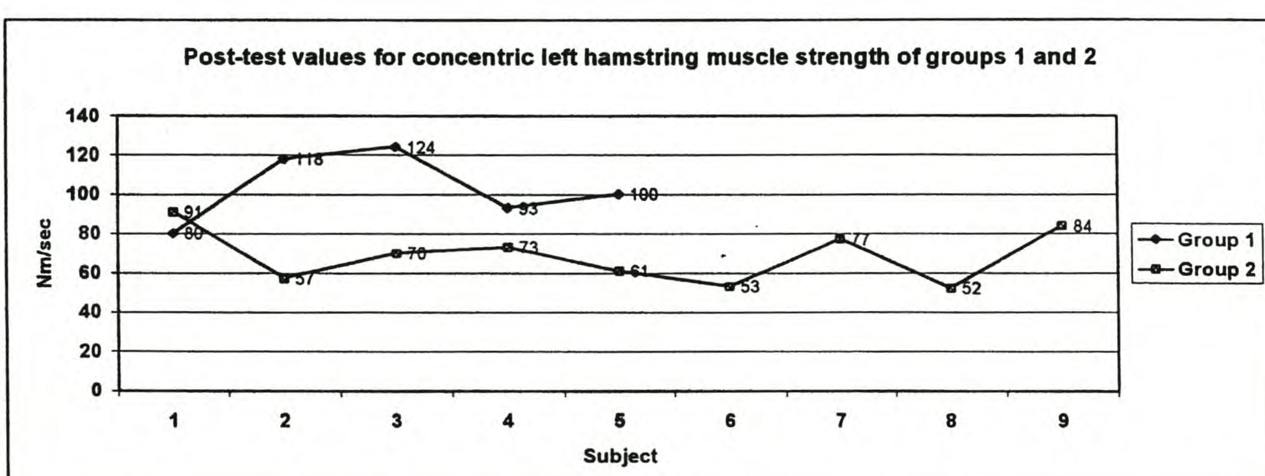


Figure 4.15: Post-test values for concentric left hamstring muscle strength of groups 1 and 2.

The minimum value of the post-test left concentric hamstring muscle strength of group 1 was 80 Nm/sec. A maximum value of 124 Nm/sec and a mean value of 103 Nm/sec (± 18.05) were recorded. For the same variable, group 2 recorded a minimum of 52 Nm/sec, a maximum of 91 Nm/sec and a mean value of 68.6 Nm/sec (± 13.88). The mean values therefore already indicate a substantial difference.

The level of participation can explain the differences between the two groups. The subjects of group 1 are subjected to more intense exercise programmes than the subjects of group 2 (in other words, they have a higher level of fitness). A higher level of muscle strength is therefore to be expected from group 1.

Figure 4.16 indicates the significant difference ($p < 0.05$) between the post-test right eccentric abductor values of groups 1 and 2. The minimum value of group 1 was 138 Nm/sec, the maximum was 181 Nm/sec and the mean value was 161 Nm/sec (± 19.2224). For the same variable, group 2 recorded a minimum value of 95 Nm/sec, a maximum value of 138 Nm/sec and a mean value of 123.6 Nm/sec (± 14.239).

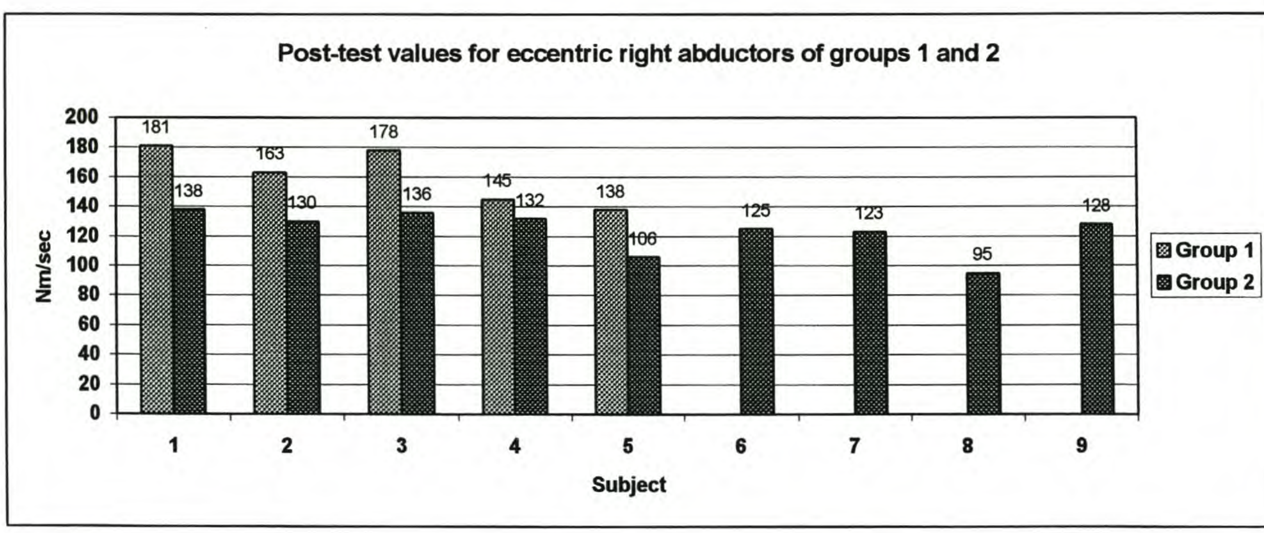


Figure 4.16: Post-test values for eccentric right abductors of groups 1 and 2.

Figure 4.17 indicates the significant difference ($p < 0.05$) between the post-test values of the right eccentric adductors of groups 1 and 2. From the graph it is clear that the eccentric adductor muscle strength of group 1 is on a much higher level than that of group 2. The maximum value of group 1 was 219 Nm/sec, the minimum value was 181 Nm/sec and the mean value was 204 Nm/sec (±

14.5258). The maximum value of group 2 was 176 Nm/sec, the minimum value was 124 Nm/sec and the mean value was 153.3 Nm/sec (± 17.5926).

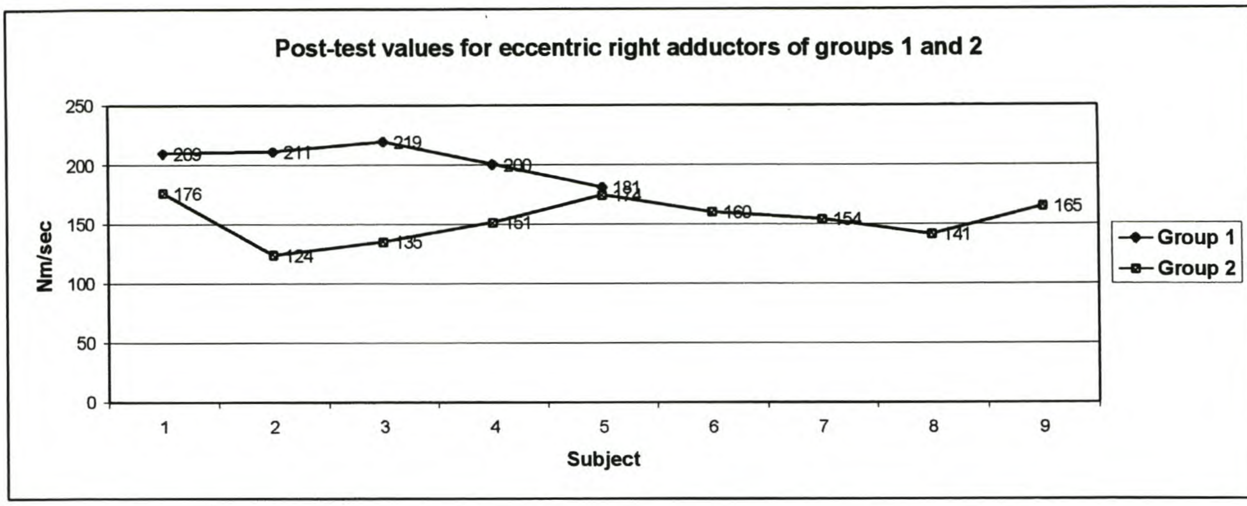


Figure 4.17: Post-test values for eccentric right adductors of groups 1 and 2.

Figure 4.18 represents the post-test values of the left concentric abductor muscle strength of groups 1 and 2. A significant difference ($p < 0.05$) is clear, although subject 1 of group 1 recorded a lower value than subject 1 of group 2. The value of subject 1 of group 1 represents the outlier (an extreme point that stands out from the rest of the distribution) of the group.

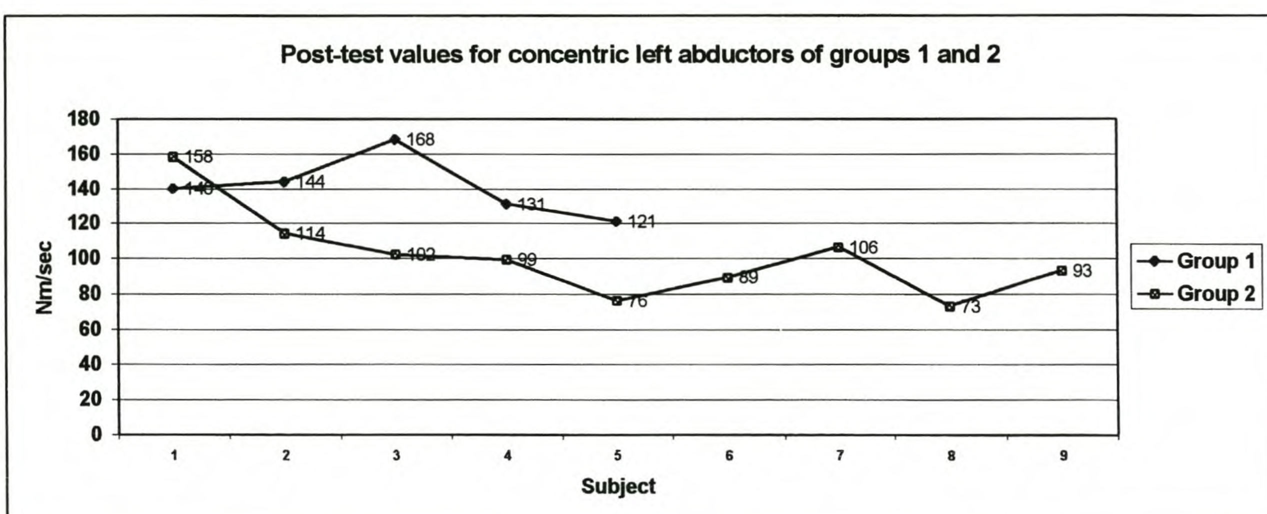


Figure 4.18: Post-test values for concentric left abductors of groups 1 and 2.

The maximum value of group 1 was 168 Nm/sec, the minimum value was 121 Nm/sec and the mean value was 140.8 Nm/sec (± 17.5983). The maximum value of group 2 was 158 Nm/sec, the minimum value was 73 Nm/sec and the mean value was 101.1 Nm/sec (± 25.1617).

Table 4.5: A summary of the values acquired for comparison between groups 1 and 2 in Nm/sec.

Group	Muscle	Minimum	Maximum	Mean
1	L con H	80	124	103
2		52	91	68.6
1	R ecc abd	138	181	161
2		95	138	123.6
1	R ecc add	181	219	204
2		124	176	153.3
1	L con abd	121	168	140.8
2		73	158	101.1

The above-mentioned statistics therefore indicates that the subjects of group 1 were on a much higher level of muscle strength regarding the individual variables than the subjects of group 2. The statistics also indicates that mainly the abductors and adductors were influenced, indicating towards the focus point of the six-week lateral movement training programme.

It is also evident from Figure 4.15 that the hamstring muscles of group 1 were much stronger than those of group 2. The hamstring muscles are the main supporters of the anterior cruciate ligaments in the knee, both serving to stabilise the knee joint. Group 1 participated in a far more strenuous exercise programme and the resulting higher level of participation therefore necessitated more stabilisation of the knee joint. Figure 4.15 indicates that the subjects of group 1 have much more support around the knee joint (i.e. stronger hamstring muscles) than the subjects of group 2.

Only the left hamstring muscles show a significant increase in muscle strength. This is probably due to the fact that most of the subjects indicated a right foot preference, the right leg would then usually work harder than the left. Consequently there is a greater margin of improvement by the weaker left side. This explains the greater increase in left hamstring muscle strength.

The post-hoc Mann-Whitney Test was also used to compare groups 1 and 3. Figure 4.19 represents the post-test values of the right eccentric abductors of groups 1 and 3, indicating a significant difference ($p < 0.05$). The maximum value of group 1 was 181 Nm/sec, the minimum value was 138 Nm/sec and the mean value was 161 Nm/sec (± 19.2224). The minimum value of group 3 was 101 Nm/sec, the maximum value was 179 Nm/sec and the mean value was 135.6667 (± 23.9531).

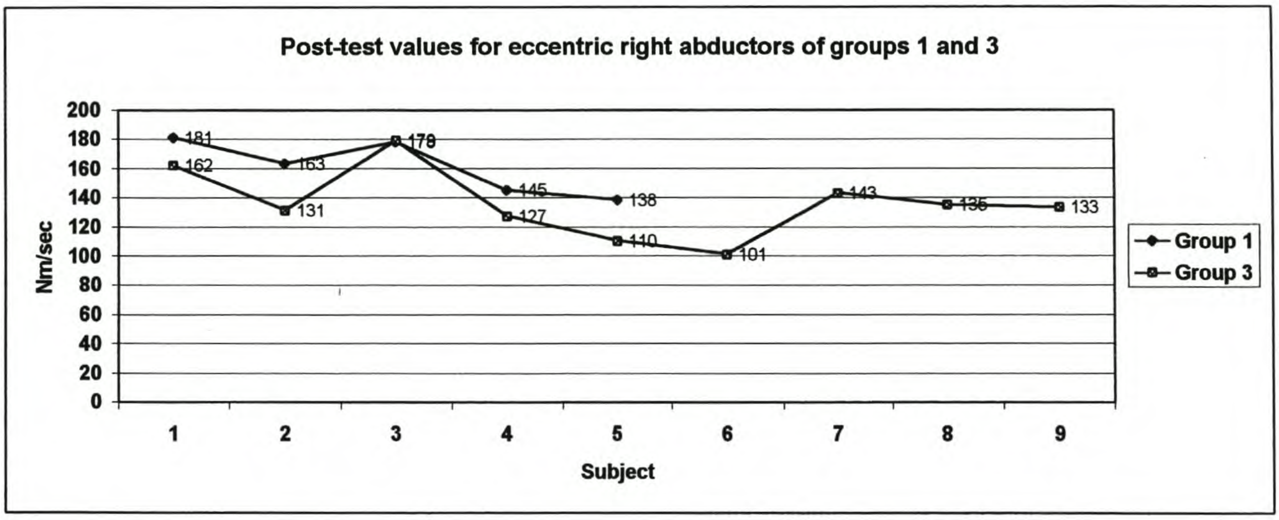


Figure 4.19: Post-test values for eccentric right abductors of groups 1 and 3.

Figure 4.20 represents the post-test values of the right eccentric adductor muscle strength of groups 1 and 3 (control group), indicating a significant difference ($p < 0.05$). The minimum value of group 1 was 181 Nm/sec, the maximum value was 219 Nm/sec and a mean value of 204 Nm/sec (±14.5285) was recorded. The minimum value of group 3 was 117 Nm/sec, the maximum value was 216 Nm/sec and the mean value was 157.88 (± 33.9354).

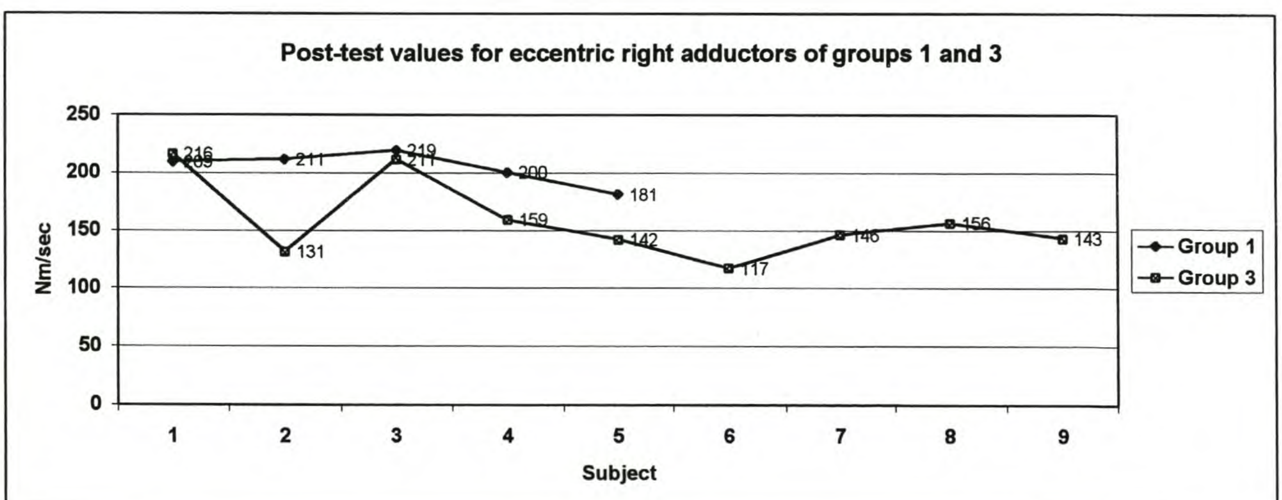


Figure 4.20: Post-test values for eccentric right adductors of groups 1 and 3.

Table 4.6: A summary of the values acquired for comparison between groups 1 and 3 in Nm/sec.

Group	Muscle	Minimum	Maximum	Mean
1	R ecc abd	138	181	161
3		101	179	135.67
1	R ecc add	181	219	204
3		117	216	157.88

The above mentioned values indicate that the six-week lateral movement training programme had an influence on muscle strength values, especially on the eccentric component of muscle strength. Since most injuries of the groin and knee areas are due to a lack of eccentric strength in the supporting muscles (i.e. the quadriceps, the hamstrings, hip abductor and adductor muscles), this is a very important factor. The conclusion can therefore be made that participation in a lateral movement training programme will enhance the eccentric strength in the hip abductor and adductor muscles, as well as in the hamstring muscles. Consequently this will increase the stability of the knee and hip joint, which will assist in the prevention of injuries.

In conclusion, it can be stated that when comparing the three groups, the lack of any significant differences ($p < 0.05$) between the pre-test values regarding the different variables (except for dynamic balance) is indicative of the fact that the subjects were relatively homogenic at the beginning of the six-week lateral movement training programme.

4.3.4 PHYSIOLOGICAL RESULTS

HEART RATE

The heart rate of the subjects of groups 1 and 2 was monitored during every exercise session. It was recorded every five minutes during the 25 – 30 minute exercise sessions.

Table 4.4 represents the mean, maximum and percentage of maximum heart rate of the subjects of groups 1 and 2 over the six-week lateral movement training period. The mean heart rate of group 1 over the six-week training period ranged from 108–130 beats/minute. The maximum heart rate (220 - age) ranged from 196–201 beats/minute. The percentage of maximum heart rate ranged from 53.7% - 66% of heart rate maximum. These figures indicate that all but one of the subjects of group 1 exercised at the American College of Sports Medicine's recommended intensity of 60% - 90% of heart rate maximum.

Table 4.7: The mean heart rate, maximum heart rate and percentage of maximum heart rate of groups 1 and 2.

Group 1			
Subject	**Mean HR**	**Maximum**	**% of Max**
N1	129	200	64.5
N2	127	197	64.4
N3	108	201	53.7
N4	120	200	60
N5	130	196	66

Group 2			
Subject	**Mean HR**	**Maximum**	**% of Max**
Res1	155	200	77.5
Res2	150	201	74.6
Res3	145	201	72.1
Res4	143	201	71.1
Res5	142	199	71.3
Res6	157	199	78.8
Res7	141	201	70.1
Res8	165	201	82
Res9	131	199	65.8

The mean heart rate of group 2 over the six-week training period ranged from 131-165 beats/ minute. The maximum heart rate (220 – age) ranged from 199-201 beats/minute and the percentage of heart rate maximum ranged from 65.8% - 82% of heart rate maximum. These figures once again indicate that all the subjects of group 2 exercised at the American College of Sports Medicine's recommended intensity of 60% - 90% of heart rate maximum.

The above-mentioned statistics indicates that the lateral movement training programme used over the six weeks met the ACSM guidelines for exercise intensity in order to elicit a training response. Regarding the percentage of heart rate maximum, it is clear from table 4.4 that even though groups 1 and 2 followed the exact same lateral movement training exercise video, group 2 exercised at a higher intensity than the subjects of group 1. This is an indication of the difference in fitness levels between the two groups. The subjects of group 1 also recorded a lower mean heart rate over the six-week period than the subjects of group 2, which is indicative of a higher level of fitness.
Figure 4.21 and 4.22 are a representation of the mean heart rate values of groups 1 and 2 over the six-week training period.

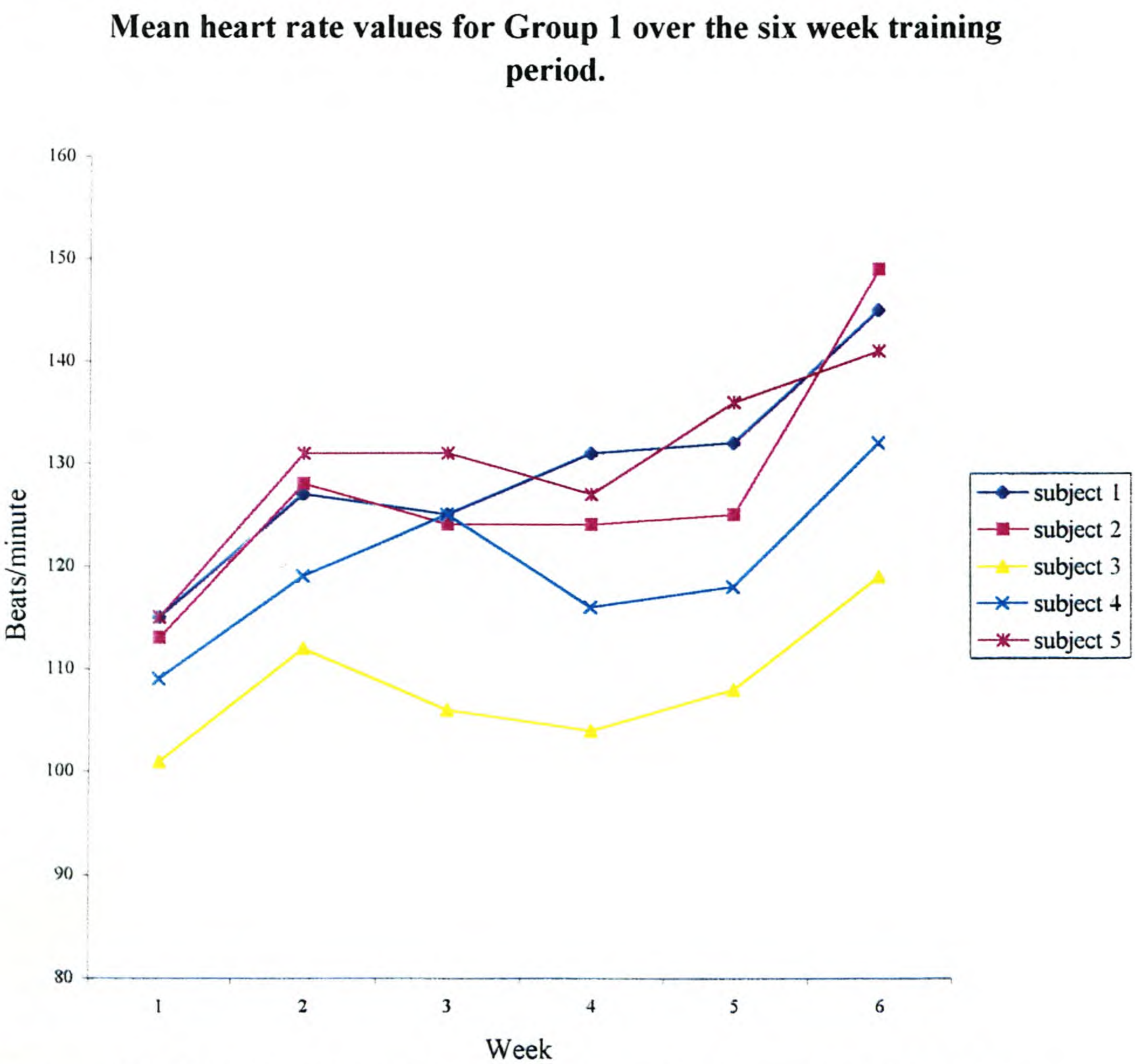


Figure 4.21: Mean heart rate values of group 1 over the six week training period.

Mean heart rate values for Group 2 over the six week training period.

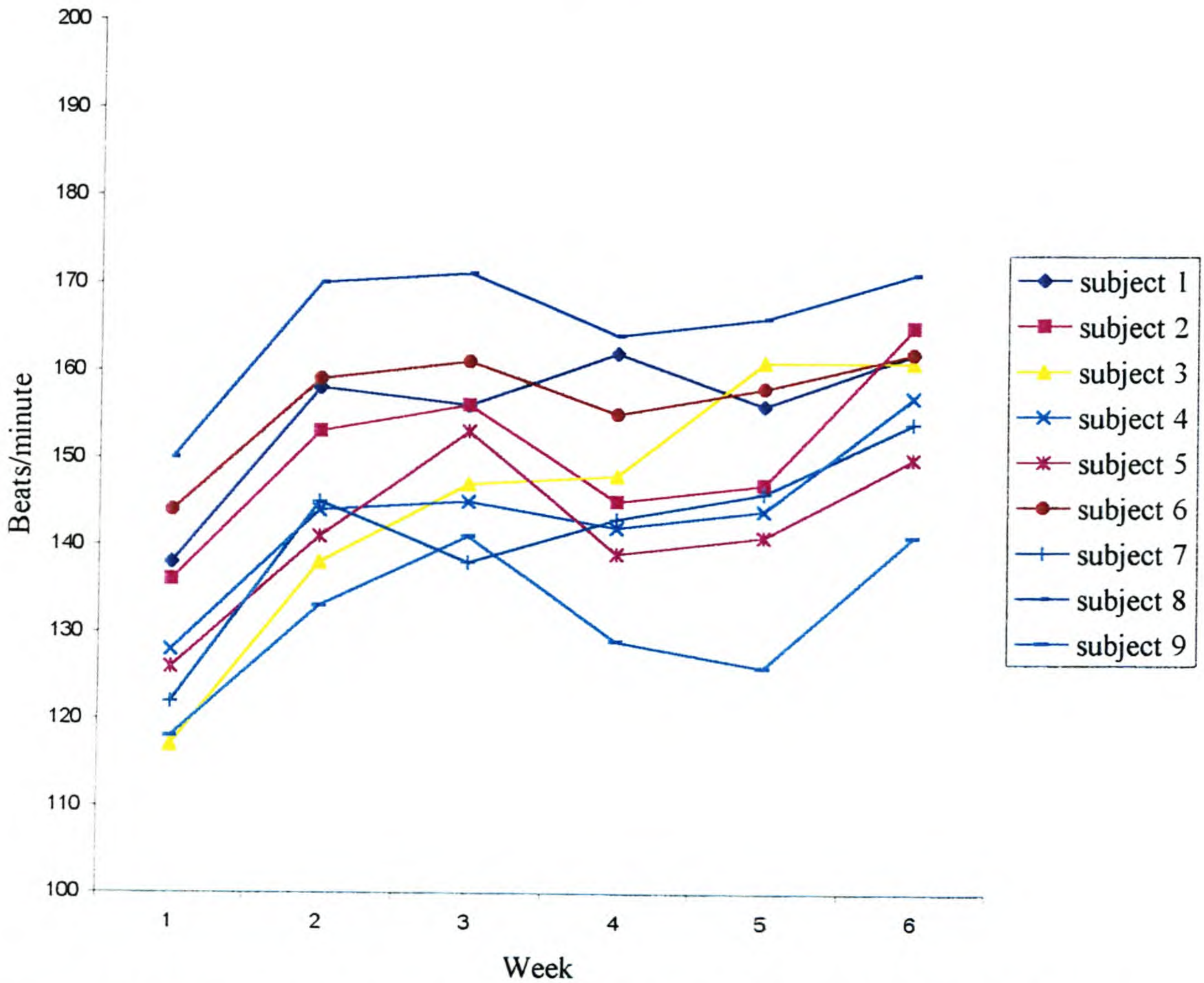


Figure 4.22: Mean heart rate values of group 2 over the six week training period.

The form of the curves clearly illustrates that all the subjects show the same heart rate responses. They all recorded a relative low heart rate during week one, which formed the introductory session to allow them to get acquainted with the technique of the slide. During week two and three, the mean heart rates rose drastically, indicating that the exercise sessions were more intense. During week four an overall drop in the mean heart rate occurred. This was due to the adaptation of the subjects' bodies to the exercise and indicating that the intensity of week four may not have been high enough. During week five an increase in mean heart rate was recorded, indicative of a more intense workload. Finally, during week six, an overall sharp increase in heart rate was recorded, indicative of a high intensity workout.

It can be concluded from Figures 4.21 and 4.22 that the exercise sessions elicited a good heart rate response. It can also be deduced that there was a relative increase in intensity in the lateral movement training exercise programme each week. The programme's intensity was therefore high enough to elicit a training response every week.

Figures 4.23 and 4.24 represent the maximum heart rate values for groups 1 and 2 over the six-week training period. As mentioned, the subjects of group 1 had a lower maximum heart rate than the subjects of group 2, indicative of the higher level of fitness (aerobic) of group 1.

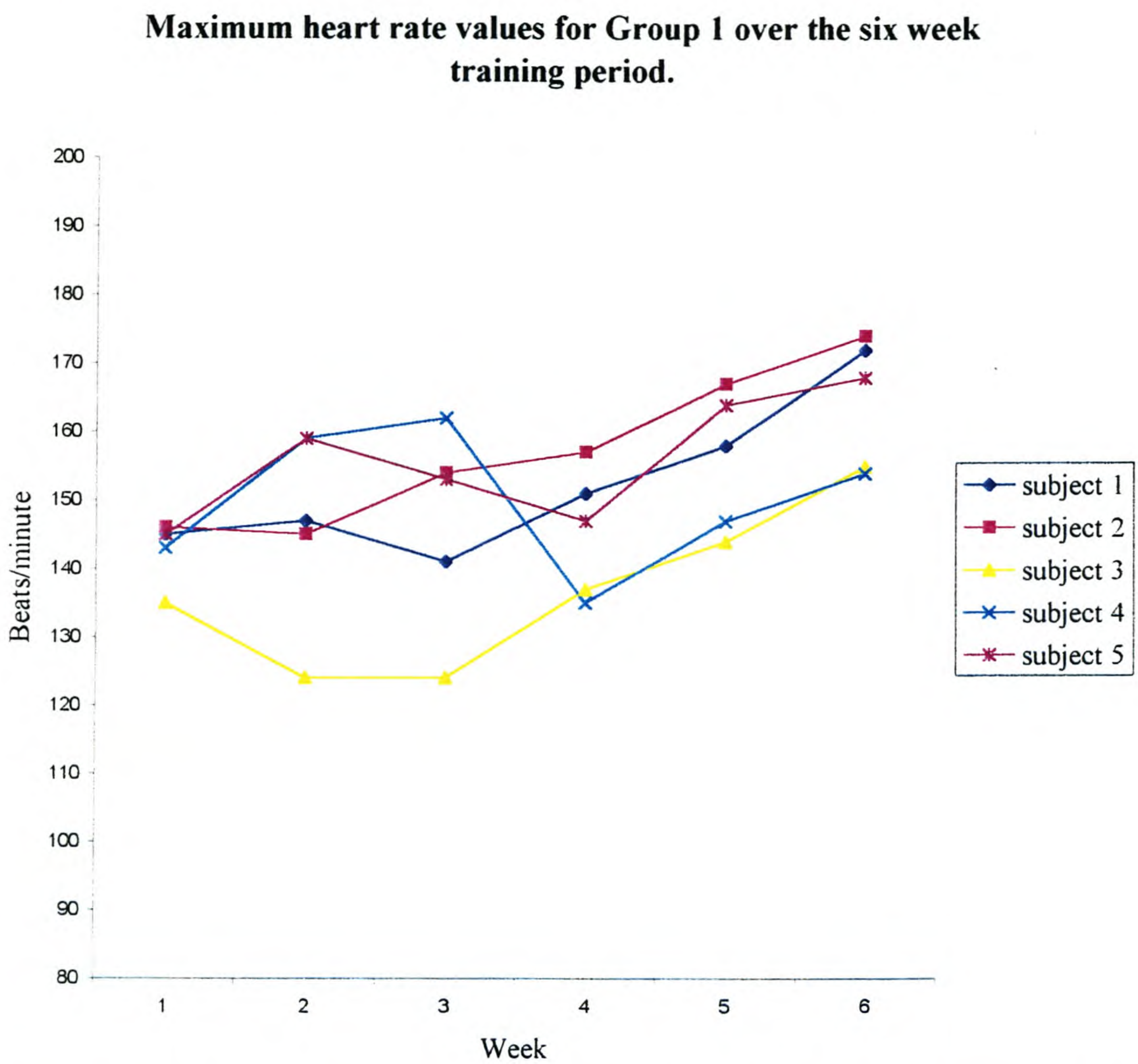


Figure 4.23: Maximum heart rate values of group 1 over the six week training period.

The maximum heart rate of group 1 increased relatively linearly every week, except for subject 4 who recorded a lower maximum heart rate after three weeks. This can be explained by the fact that the subject could no longer attend her exercise sessions in the afternoons due to work obligations. Subject 4 therefore scheduled early morning sessions from week four onwards. Heart rate is usually lower in the mornings, explaining the difference.

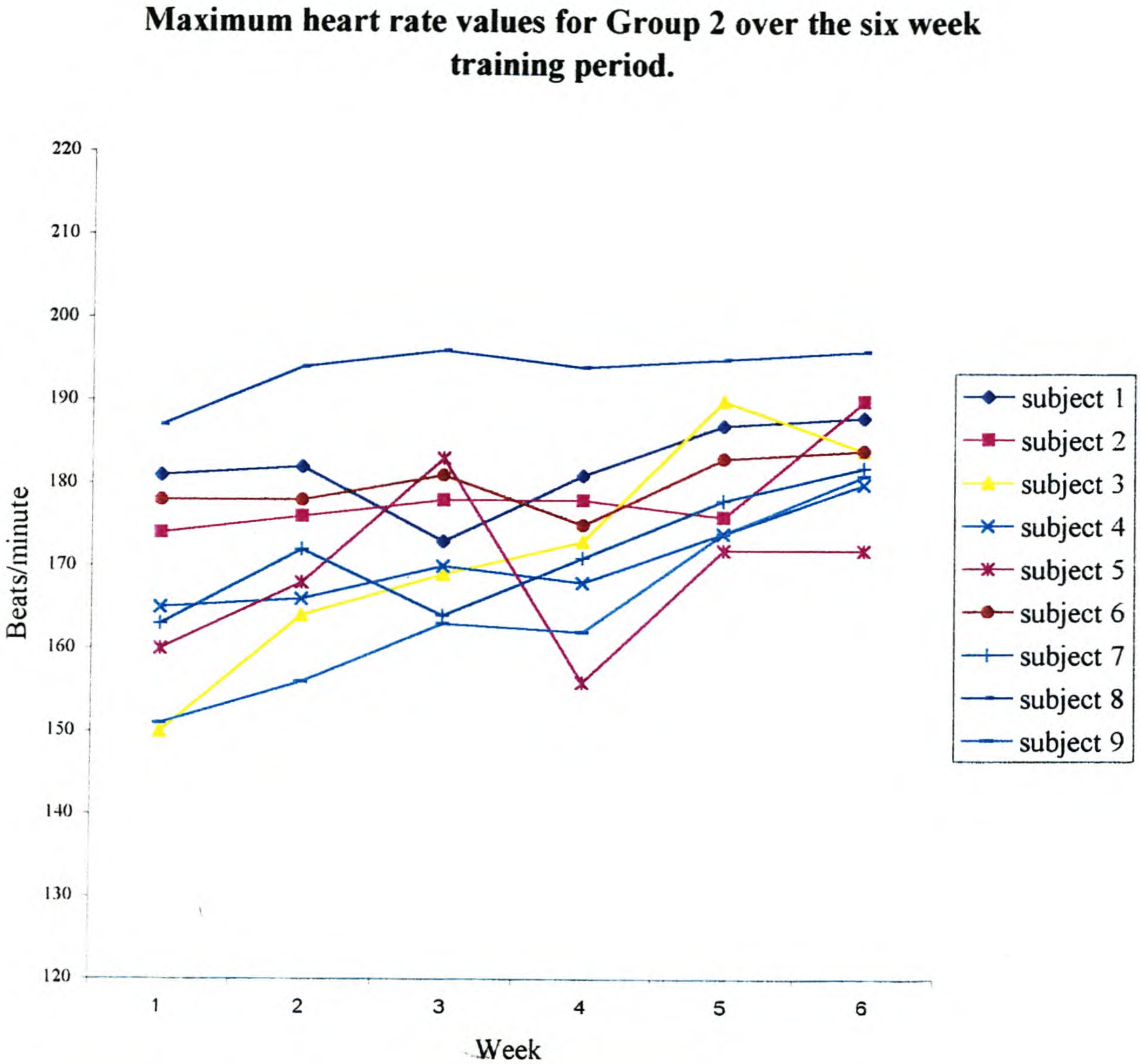


Figure 4.24: Maximum heart rate values of group 2 over the six week training period.

Group 2 also showed a relative increase in maximum heart rate, except for subject 5. She had a mild case of the flu during week 4, which usually quickly leads to weakening of the overall body stamina and strength. This could explain the lower maximum heart rate values of subject 5 in weeks 4 - 6.

Interestingly subject 8 of group 2 nearly always exercised close to her predicted maximum heart rate, indicating that the exercise intensity of the six-week training programme was high, but not dangerous, for her level of fitness.

In conclusion it can be stated that the six-week lateral movement training video elicited a high enough heart rate response to fulfil the requirements of the American College of Sports Medicine.

The different heart rate responses between groups 1 and 2 are due to the difference in fitness levels. The inter-group differences can be explained by the different leg lengths of the subjects. The shorter the leg length, the harder the subject has to work to slide from one side to the other. The taller the subject, the easier it is to slide from one side to the other.

It must also be stated that the small sample size of each group had a limiting effect on the statistical power. This restricted the ability to detect small differences, as well as non-significant changes.

CHAPTER FIVE

CONCLUSION

After the six-week lateral movement training intervention programme and the interpretation of the acquired data, the following conclusions are drawn:

Null hypothesis accepted: improvement of selected physiological aspects in netball players by means of lateral movement training or slide board training.

Hypothesis 1 rejected: Lateral movement training did not increase thigh and calf girth measurements, but rather had a maintenance effect with the accompanied toning of thigh and calf muscles.

Hypothesis 2 accepted: Lateral movement training decreased the body fat percentage.

Hypothesis 3 accepted: Lateral movement training decreased overall body mass.

Hypothesis 4 accepted: Lateral movement training increased lateral agility, especially that of the residence netball players.

Hypothesis 5 rejected: Lateral movement training did not increase lateral flexibility, because no extensive stretching programme was followed.

Hypothesis 6 accepted: Lateral movement training lead to a better dynamic balance, especially with regards to the residence netball players.

Hypothesis 7 accepted: Lateral movement training increased concentric and eccentric abductor and adductor strength, but not concentric and eccentric quadriceps and hamstring muscle strength.

Hypothesis 8 accepted: Lateral movement training meets the ACSM guidelines for aerobic exercise in terms of heart rate response; i.e. a heart rate of 60% - 90% of heart rate maximum.

RECOMMENDATIONS FOR FUTURE RESEARCH

1. In the course of the research programme this researcher realised that too many variables were being investigated, making it difficult to research every detail of each variable. It is suggested that future research focuses only on one or two physiological aspects of a lateral movement training programme.

2. This researcher experienced difficulty with co-ordinating the two different groups. Each group of subjects was very large, which created problems in terms of organisation. In future researchers should rather focus on one group, for example just the club netball players.

3. It is recommended that a following researcher should control the subjects' exercise regimes outside the lateral movement training programme better. This should facilitate explanations regarding the changes in variables, or the lack thereof.

4. The use of adjustable slide boards is recommended. This will accommodate the different leg lengths of the subjects. By doing so, control of the intensity of the lateral movement training programme is enhanced.

5. It is advisable to control the time of day each subject exercises. Different times of the day elicit different training responses, which create problems when comparing groups.

6. It would be interesting to investigate the influence of a lateral movement training programme in the prevention of knee injuries in different sports containing a lateral movement component, since the research indicated that lateral movement training has a positive effect on the stabilising muscles of the knee.

7. A more specific stretching regime should be incorporated into the lateral movement training programme in order to enhance lateral flexibility (possible influence on injuries).

8. It would also be interesting to investigate the effectiveness of a lateral movement training programme as a cross-training mode for runners, especially those with tibial stress fractures.

In conclusion the lateral movement training programme proved to be very beneficial to the participating subjects. For the 1st and 2nd team club netball players the programme provided an excellent aerobic workout, with either improvement or maintenance in the selected variables.

For the 1st and 2nd team residence netball players the programme once again provided an excellent aerobic workout, with improvement or maintenance in all eight of the selected variables.

The programme also provided a much-needed cross-training regime, which elicited a positive social and physiological effect from the participants. Especially those subjects who did not feel comfortable with the traditional training programmes, consisting of jogging, showed great enjoyment of the programme.

The researcher highly recommend a lateral movement training programme to netball players at any level of fitness and participation, provided that participants undergo an extensive pre-screening investigation to rule out the possibility of aggravation of previous injuries. The possible negative effects of a lateral movement training programme are insignificant in comparison with the proven beneficial results thereof, not only as a functional cross-training regime, but also as a possible preventative mechanism for various injuries.

APPENDIX A

PRE-TEST QUESTIONNAIRE

1. In which sports do you participate for leisure?..
2. In which sport(s) do you take part competitively? (Res or club and in which team)..
3. Have you ever had any knee, ankle, or lower back problems? ....
4. If so, how long ago and how did the injury occur? ....
   ....
   ....
5. Did you receive any treatment for the injury, and if so what kind?....................
   ....
   ....
   ....
6. Highest achievement in sport? (which sport)...
   ....
7. Do you have normal eating habits (that is regular balanced meals)?..................
   ....
8. Do you eat breakfast? What?..
9. Do you eat lunch? What?..
10. Do you eat supper? What?..
11. Have you recently gained or lost more than 3kg?.......................................
12. Have you ever had Bulimia or Anorexia Nervosa?......................................
13. Do you participate in regular aerobic exercise (eg. Jogging, swimming etc.).........
    ....
14. Have you participated in slide board training before?.................................
15. Do you think you will benefit from slide board training?...............................
16. How late do you go to bed?..
17. How late do you get up in the mornings?..
18. Are you on permanent medication?...
19. Do you have any permanent disease (eg. Diabetes)?...................................
20. Why do you want to participate in this research project?..............................
    ....

APPENDIX B

Informed consent for Exercise Testing and a six-week Training Programme

1. Purpose and explanation of tests and programme:

I hereby consent to voluntary engage in exercise tests to determine my heart rate response during a specific exercise, lateral agility, lateral flexibility, upper leg strength, dynamic balance and fat percentage, as well as participation in a six-week slide board training programme which consists of three sessions a week of ± 45 minutes each.

Before I undergo the tests, I certify to the programme that I am in good health and have currently no known hip, knee, ankle or lower back problems/injuries. I understand that it is important that I provide complete and accurate responses to the test supervisor and recognise that my failure to do so could lead to possible injury to myself during the tests and training programme.

It is my understanding and I have been clearly advised that it is my right to request that a test/training session be terminated at any point if I feel unusual discomfort or fatigue. My wishes in this regard shall be absolutely carried out.

I realise that a true determination of my capacity during above mentioned tests and training programme depends upon me performing them to the best of my ability.

2. Risks:

I understand and have been informed that there exists the possibility of changes during and after the tests and training programme. These changes could include delayed onset muscle soreness (that is muscle stiffness). I understand that there are minimal risks of injury as a result of my performance of the tests and training programme, but knowing those risks, it is my desire to proceed to undertake the tests and training programme.

3. Benefits to be expected:

The results of these tests and training programme may or may not benefit me. Potential benefits could include a lower body fat percentage, better balance, lateral agility, lateral flexibility and an increase in upper leg strength, which may or may not help in the prevention of knee injuries.

4. Confidentiality and use of information:

I have been informed that the information obtained in these exercise tests and training programme will be treated as privileged and confidential and will consequently only be used for research and statistical purposes.

APPENDIX B

5. **Inquiries and freedom of consent:**

I have been given the opportunity to ask certain questions as to the procedures. I further understand that there are remote risks associated with these procedures, but I still wish to proceed with the tests and training programme.

I acknowledge that I have read this document in its entirety or that it has been read to me if I have been unable to read.

Date:................................ ....

(Participant's signature)

....

(Test supervisor's signature)

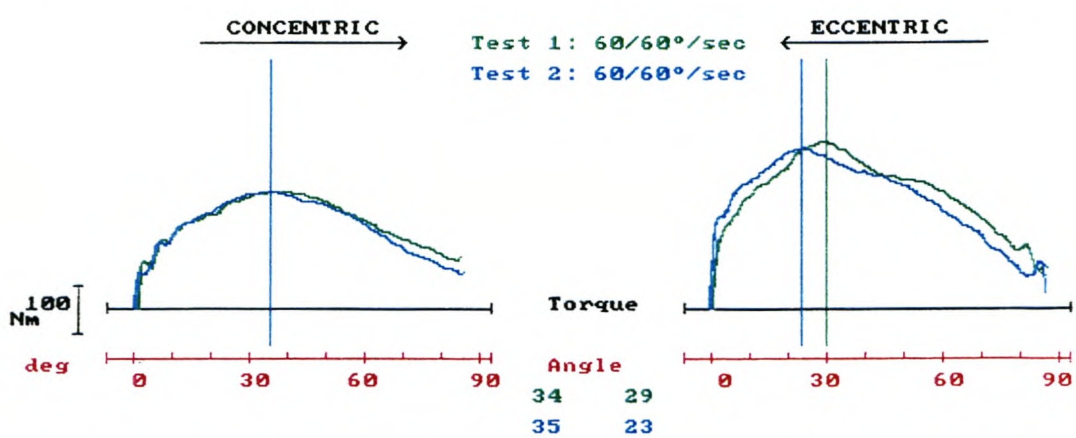
APPENDIX C

KIN-COM TEST RESULT
Version: 5.13

BIOKINETIKA LAB.
DEPT.M.B.K.
UNIVERSITEIT STELLENBOSCH
(021)-8084735

Patient : CONRADIE SANDRA
Date : 12.10.99
Joint : KNEE
Physician :
Diagnosis :

Procedures		Test ONE	Test TWO
Date	:	12.04.99	12.04.99
Side	:	RIGHT	LEFT
Muscle Grp.	:	EXT/FLEX	EXT/FLEX
Lever Arm	:	33 cm	33 cm
Angles	:	0 to 86 deg	0 to 87 deg
R-T Gravity	:	23 Nm	21 Nm
Velocity	:	60	60
File	:	110.CHA	110.CHA



Test ONE	:	247 Nm	RIGHT	Test ONE	:	349 Nm
Test TWO	:	243 Nm	LEFT	Test TWO	:	332 Nm
Difference	:	-1.6 %		Difference	:	-4.7 %

Assessment: Graph 1:Right and Left Quadriceps concentric
Graph 2:Right and left Quadriceps eccentric

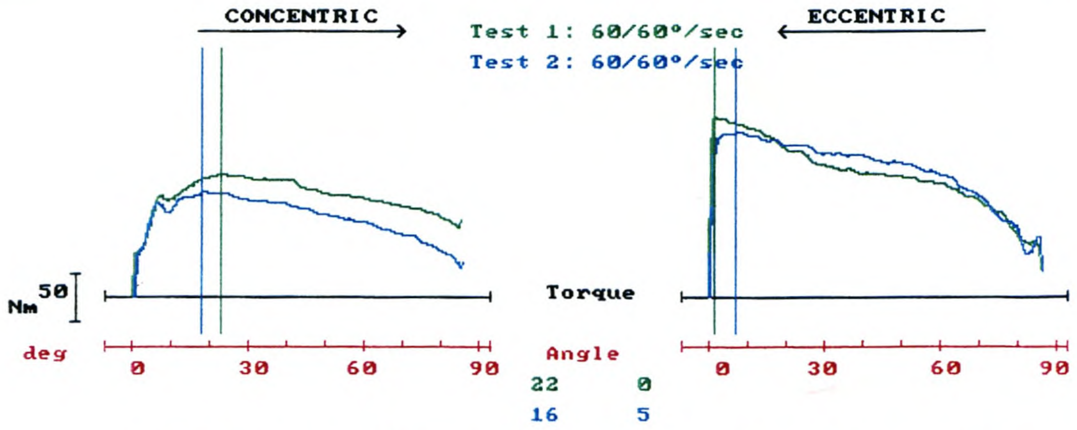
APPENDIX C

KIN-COM TEST RESULT
Version: 5.13

BIOKINETIKA LAB.
DEPT.M.B.K.
UNIVERSITEIT STELLENBOSCH
(021)-8084735

Patient : CONRADIE SANDRA
Date : 12.10.99
Joint : KNEE
Physician :
Diagnosis :

Procedures		Test ONE	Test TWO
Date	:	12.04.99	12.04.99
Side	:	RIGHT	LEFT
Muscle Grp.	:	EXT/FLEX	EXT/FLEX
Lever Arm	:	33 cm	33 cm
Angles	:	0 to 86 deg	0 to 87 deg
R-T Gravity	:	23 Nm	21 Nm
Velocity	:	60	60
File	:	110.CHA	110.CHA



Test ONE	:	128 Nm	RIGHT	Test ONE	:	187 Nm
Test TWO	:	110 Nm	LEFT	Test TWO	:	173 Nm
Difference	:	-13.7 %		Difference	:	-7.8 %

Assessment: Graph 1:Right and Left Hamstring concentric
Graph 2:Right and left Hamstring eccentric

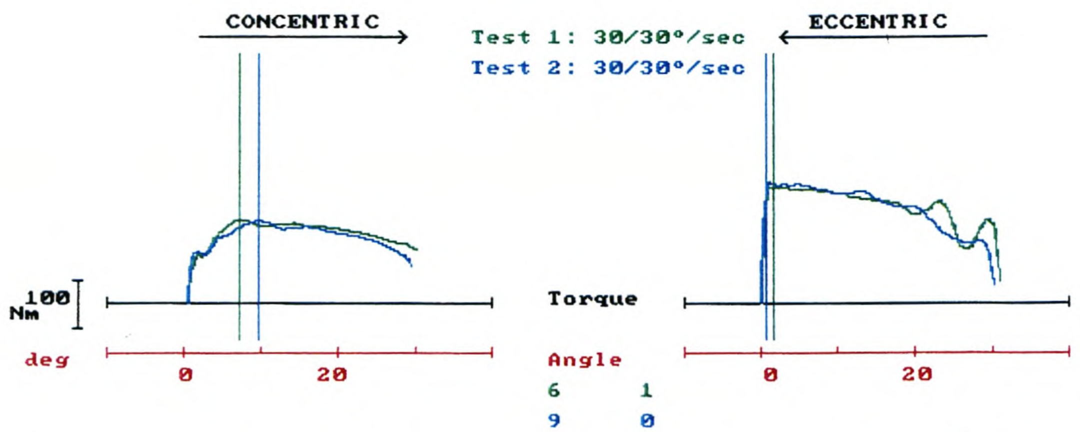
APPENDIX C

KIN-COM TEST RESULT
Version: 5.13

BIOKINETIKA LAB.
DEPT.M.B.K.
UNIVERSITEIT STELLENBOSCH
(021)-8084735

Patient : CONRADIE SANDRA
Date : 12.10.99
Joint : HIP
Physician :
Diagnosis :

Procedures		Test ONE	Test TWO
Date	:	12.04.99	12.04.99
Side	:	RIGHT	LEFT
Muscle Grp.	:	AB/AD	AB/AD
Lever Arm	:	64 cm	64 cm
Angles	:	0 to 30 deg	0 to 30 deg
Velocity	:	30	30
File	:	111.CHA	111.CHA



Test ONE	:	175 Nm	RIGHT	Test ONE	:	243 Nm
Test TWO	:	169 Nm	LEFT	Test TWO	:	249 Nm
Difference	:	-3.2 %		Difference	:	2.3 %

Assessment: Graph 1:Right and Left Adductor concentric
Graph 2:Right and Left Adductor eccentric

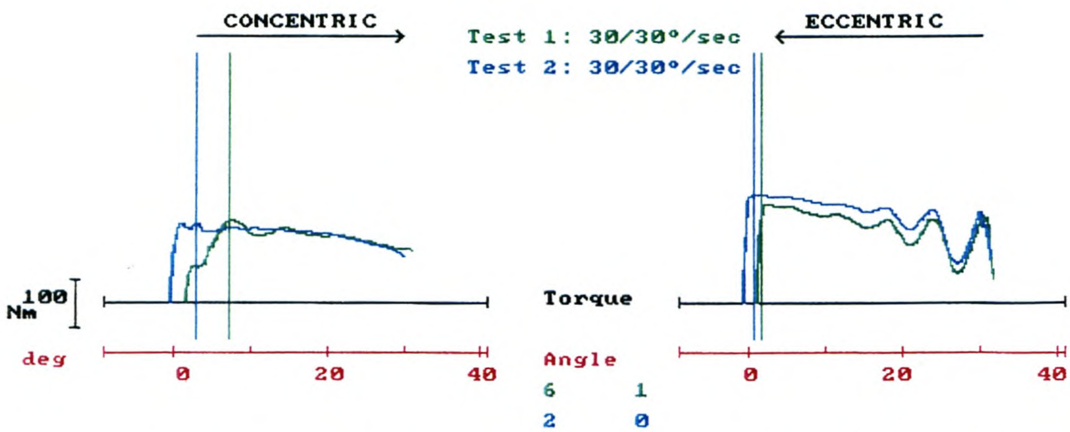
APPENDIX C

KIN-COM TEST RESULT
Version: 5.13

BIOKINETIKA LAB.
DEPT.M.B.K.
UNIVERSITEIT STELLENBOSCH
(021)-8084735

Patient : CONRADIE SANDRA
Date : 12.10.99
Joint : HIP
Physician :
Diagnosis :

Procedures		Test ONE	Test TWO
Date	:	12.04.99	12.04.99
Side	:	RIGHT	LEFT
Muscle Grp.	:	AB/AD	AB/AD
Lever Arm	:	64 cm	64 cm
Angles	:	1 to 31 deg	0 to 30 deg
Velocity	:	30	30
File	:	111.CHA	111.CHA



Test ONE	:	170 Nm	RIGHT	Test ONE	:	204 Nm
Test TWO	:	167 Nm	LEFT	Test TWO	:	226 Nm
Difference	:	-1.5 %		Difference	:	10.8 %

Assessment: Graph 1:Right and Left Hip Abductor concentric
Graph 2:Right and Left Hip Abductor eccentric

APPENDIX D

PRE-TEST
SLIDE PROJECT

Name:……………………………………………………
Age:……………
Gender:……………………………
Date:……………
Mass:…………………..(kg)
BP:……………..

1. **Heights**: Stature:…………………..(cm)
Trochanterion:…………..(cm)
Tibialis Externum:……….(cm)

2. **Girths:** Thigh:R………L……….(cm)
Calf: R………L……….(cm)

3. **Fat%:** Skinfolds: Triceps:……………..
Biceps:……………..
Supscapular:……….
Chest:………………
Axilla:………………
Supra-iliac:………..
Abdominal:…………
Thigh:………………
Calf:…………………

4. **Agility:** Agility T/Side Step Test 1)……………….(s)
2)……………….(s)
Best time:………………..(s)

APPENDIX D

5. <u>Flexibility</u>: (Protractor) R 1)………. 2)………….3)…………
L 1)………..2)………….3)…………
(Side-step-test) 1)………..2)………….3)…………

6. <u>Kin Com Test</u>: L flex/ext:…………….
R flex/ext:…………….
L abd/add:……………
R abd/add:……………

7. <u>Dynamic Balance:</u> (Modified Bass Test)

1. L…….
   B…….
2. L…….
   B…….
3. L…….
   B…….
4. L…….
   B…….
5. L…….
   B…….
6. L…….
   B…….
7. L…….
   B…….
8. L…….
   B…….
9. L…….
   B…….
10. L…….
    B…….

TOTAL: ………/100

APPENDIX E

POST-TEST
SLIDE PROJECT

Name:...
Age:...............
Gender:...............................
Date:...............
Mass:.......................(kg)
BP:................

1. Heights: Stature:.......................(cm)
Trochanterion:...............(cm)
Tibialis Externum:..........(cm)

2. Girths: Thigh:R.........L..........(cm)
Calf: R.........L..........(cm)

3. Fat%: Skinfolds: Triceps:................
Biceps:..................
Supscapular:..........
Chest:..................
Axilla:.................
Supra-iliac:...........
Abdominal:...........
Thigh:..................
Calf:....................

4. Agility: Agility T/Side Step Test 1)..................(s)
2)..................(s)
Best time:..................(s)

APPENDIX E

5. Flexibility: (Protractor) R 1).......... 2)............3)............
L 1)...........2)............3)............
(Side-step-test) 1)...........2)............3)............

6. Kin Com Test: L flex/ext:...............
R flex/ext:...............
L abd/add:..............
R abd/add:..............

7. Dynamic Balance: (Modified Bass Test)

1. L.......
   B.......
2. L.......
   B.......
3. L.......
   B.......
4. L.......
   B.......
5. L.......
   B.......
6. L.......
   B.......
7. L.......
   B.......
8. L.......
   B.......
9. L.......
   B.......
10. L.......
    B.......

TOTAL: ..../100

APPENDIX F

SESSION EVALUATION:HEART RATE

Session	BW	AW	Begin	5min	10min	15min	20min	22min	25min	BC	AC	MAX
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												

Position:

APPENDIX G

SESSION ONE

Warm-up

10-minutes

Routine on slide board

Toe-taps - slow singles	×8
- fast singles	×8
- both feet together	×8
Heel raises	×8
Hip rotations - L & R	×12
- together	×12
Lateral leg extensions	×12 (L & R)
	×4 (L & R)
	×2 (L & R)
	×8 (Singles)
Hip rotation	×8
Lateral leg extensions	×4 (L & R)
	×2 (L & R)
Hip rotations - narrow	×8
- wide	×8
Lateral leg extension - wide	×8
Twists - feet parallel	×8
- travelling	×2
Shuffles - fwd & back	×2
- side to side	×2
Twists - in the centre of slide	×8
Lateral leg extension	×16 (singles)

APPENDIX G

Side push to centre and shuffle back to start	×4
Side push ¾ across and shuffle to other side	×16
Slide to centre and shuffle to other side	×8 (L & R)
Single slide + hold feet together	×12
Lateral leg extensions	×12 (L & R)
Single slide + hold - slow time	×20
- double time 2's	×4
4's	×4
8's	×2
Squats side of slide	×12
Single slide + hold	×8
Repeated	×6
Single squats off side of slide	×6 sets of 4 and 8

Stretch

5 minutes

SESSION TWO

Warm-up

10 minutes

Routine on slide board

Hip rotations	×8
Lateral leg extension	×8
Twists	×12
Shuffle to centre and back	×4
Slide ¾ and shuffle across	×16
Single slide and hold	×16
Single slide and bend	×20

APPENDIX G

Backward lunges - small	×8
- large	×16
Single slide and bend	×10
Backward lunges	×20
Lateral leg extensions	×20 (L & R)
Single slide and bend	×4
Single, bend and two extensions	×12
Backward lunges - singles	×16
- doubles	×8
Basic slide and hold	×4
Single and toe front	×8
Basic slide and hold	×4
Basic slide	×16
Single and toe front	×4
Single, toe front and knee lift	×12
Basic slide	×16
Single, toe front and knee lift	×8
Single, bend and two extensions	×4
Basic slide	×8
Single toe front and knee lift	×4
Backward lunges - singles	×16
- doubles	×8
Single, bend and two extensions	×4
Basic slide	×8
Single, toe front and knee lift	×8
Single, bend and two extensions	×4
Basic slide	×8
Single, toe front and knee lift	×4
Basic slide	×16
Backward lunges - singles	×20
- doubles	×12

APPENDIX G

Single, bend and two extensions	×4
Basic slide	×8
Single, toe front and knee lifts	×4
Basic slide	×8
Squats off the side of the slide - singles	×16
- knee lifts	×8

Stretch

5 minutes

SESSION THREE

Warm-up

10 minutes

Routine on slide board

¾ across and shuffle	×4
Basic slide	×16
Lateral extensions - L	×15 and slide across
- R	×15 and slide across
- L	×7 and slide across
- R	×7 and slide across
Basic slide	×16
Three extensions, single	×4
Basic slide	×8
Single and bend	×8
Single, bend and two extensions	×8
Basic slide	×8
Single and bend	×24

APPENDIX G

Centre - abd/adductor contractions	×24
Basic slide	×4
Single, bend and two extensions	×4
Single and bend	×8
Centre - abd/adductor contractions	×24
Basic slide	×8
Single, one lateral extension	×20
Basic slide	×8
Single, bend and two extensions	×4
Single and bend	×16
Single, one lateral extension	×16
Centre, - abd/adductor contractions	×16
Basic slide	×8
Single, bend and two extensions	×4
Single and bend	×8
Single, one lateral extension	×8
Repeat above	
Basic slide	×12
Single and toe front	×20
Single, toe front and knee lift	×8
Single and knee lift	×8
Basic slide	×8
Single, bend and two extensions	×4
Single and bend	×8
Single, one lateral extension	×8
Single and toe front	×8
Single, toe front and knee lift	×4
Single and knee lift	×16
Basic slide	×8
Centre - abd/adductor contractions	×24
Basic slide	×8

APPENDIX G

Single, bend and two extensions	×4
Single and bend	×8
Single, one lateral extension	×8
Single and toe front	×8
Single and knee lift	×16
Backward lunges - singles	×20
- doubles	×8
Centre - abd/add contractions	×12
Basic slide	×10
Single, bend and two extensions	×4
Single and bend	×16
Single, one lateral extension	×8
Single and toe front	×8
Single and knee lift	×16
Basic slide	×4
Backward lunges - singles	×12
Squats off the side of the slide - singles	×8
- knee lifts	×8
- double time	×16

<u>Stretch</u>

5 minutes

<u>SESSION FOUR</u>

<u>Warm-up</u>

10 minutes

<u>Routine on slide board</u>

Basic slide	×24

APPENDIX G

Single, hold and bend	×8
Basic slide	×8
Single, hold and bend	×4
Single and bend	×16
Basic slide	×8
Single and bend	×8
Single, bend, one extension	×16
Basic slide	×8
Single and one extension	×8
Basic slide	×8
Single and one extension	×8
Basic slide	×8
Single and toe front	×16
Single and knee lift	×16
Basic slide	×8
Single and bend	×8
Single, bend, one extension	×8
Single, bend, two extension	×8
Basic slide	×8
Single and one extension	×8
Single and toe front	×8
Single and knee lift	×16
Centre - abd/adductor contractions	×24
- small squats	×24
Basic slide	×8
Single and bend	×8
Single, bend, two extensions	×8
Single and toe front	×8
Single and knee lift	×16
Basic slide	×8
Single and toe behind	×32

APPENDIX G

Backward lunges - singles	×8
- doubles	×8
Basic slide	×8
Single and bend	×8
Single, bend, two extensions	×8
Single and toe front	×8
Single and knee lift	×16
Single and toe behind	×16
Side - hip rotations	×8
Basic slide	×7
Repeat above	
Three singles (double time), hold	×4
Basic slide	×16
Three singles (double time), hold	×4
Basic slide	×16
Centre - backward lunges (slow)	×8
- backward lunges (double time)	×16
Basic slide	×4
Single and bend	×4
Single, bend, two extensions	×4
Single and toe front	×8
Single and knee lift	×8
Single and toe behind	×16
Three singles (double time), hold	×8
Basic slide	×8
Centre - abd/add contractions	×16
- small squats	×16
- backward lunges (singles)	×24
squats off the side of the slide - singles	×16
- knee lifts	×16
- double time	×16

APPENDIX G

Stretch

5 minutes

SESSION FIVE

Warm-up

8 minutes

Routine on slide board

Explain and teach fencing 1 & 2

Basic slide	×16
Fencing 1	×8
Basic slide	×8
Fencing 2	×8
Fencing 1	×12
Fencing 2	×12
Squats - narrow	×8
Basic slide	×8
Fencing 1	×8
Fencing 2	×8
Squats - narrow	×8
Basic slide	×8
Single and bend	×16
Fencing 1	×8
Fencing 2	×8
Basic slide	×8
Single and bend	×8
Single, bend, one extension	×16
Single and bend	×8

APPENDIX G

Single, lateral leg raise	×16
Single, bend, leg raise	×8
Single and toe front	×8
Single and knee lift	×8
Fencing 1	×8
Fencing 2	×8
Single and bend	×8
Single, bend, one extension	×8
Single, bend, leg raise	×8
Single and knee lift	×16
Single and toe behind	×16
Two singles, four double time	×4
Centre - abd/adductor	×12
- small squats	×16
- alternating above	×8
Basic slide	×8
Fencing 1	×8
Fencing 2	×16
Single and bend	×8
Single, bend, leg raise	×8
Single and knee lift	×12
Single and toe behind	×8
Two singles, four double time	×4
Backward lunges	×8
Centre - backward lunges	×24
- double time	×16
Basic slide	×16
Fencing 1	×8
Fencing 2	×8
Single and bend	×8
Single, bend, leg raise	×12

APPENDIX G

Single and knee lift	×16
Single and toe behind	×16
Two singles, four double time	×8
Centre - lateral lunges	×16
- double time	×8
- lateral lunges	×4
- double time	×4
Repeat	
- narrow squats	×8
- wide squats	×12
Two singles, four double time	×8
Squats off the side of the slide	×16

<u>Stretch</u>

5 minutes

<u>SESSION SIX</u>

<u>Warm-up</u>

8 minutes

<u>Routine on slide board</u>

Basic slide	×8
Centre - lateral lunges	×16
Repeat above	
Fencing 1	×12
Fencing 2	×8
Repeat above	
Basic slide	×8
Single and bend	×8
Single, bend, one extension	×4

APPENDIX G

Fencing 1	×8
Fencing 2	×8
Repeat above twice	
Three singles double time	×8
Basic slide	×8
Three singles double time	×4
Basic slide	×4
Single and toe front	×8
Single and knee lift	×12
Single, knee lift, bend	×8
Single, knee lift, two bends	×8
Three singles double time	×8
Fencing 1	×8
Fencing 2	×8
Single and bend	×8
Single, bend, one extension	×4
Three singles double time	×8
Single and knee lift	×4
Single, knee lift, bend	×2
Single, knee lift, two bends	×4
Basic slide	×8
Single and lateral raise	×8
Four singles, eight double time	×4
Basic slide	×4
Centre - backward lunges	×16
- double time	×16
Side - single squats	×20
- with knee lift	×16
Basic slide	×4
Single and toe behind	×12
Single and hamstring curl	×16

APPENDIX G

Centre - abd/adductor	×16
- narrow squats	×8
- alternate	×8
Basic slide	×12
Repeated twice:	
Fencing 1	×8
Fencing 2	×8
Single and bend	×8
Single, bend, one extension	×4
Single and knee lift	×8
Single, knee lift, two bends	×8
Three singles double time	×8
Single and hamstring curl	×8
Four singles, eight double time	×4
Basic slide	×8
Squats off the end of the slide	×16

<u>Stretch</u>

5 minutes

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