ITTF longer reach table tennis experiment; Does a longer table promote more rallies and physical fitness in South African players?

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Abstract In recent years competitive table tennis has been criticized as not producing long rallies because of over reliance on advancement in rubber technology, which not only yields the required spin and speed but also reduces players' athletic effort. An experiment was carried out to provide a scientific basis for evaluating the effectiveness of longer reach table tennis in promoting more rallies and athletic effort among players as compared to conventional table tennis. The experiment involved 11 South African national players in junior (U-14) and senior categories. The players were matched for playing ability and assigned to two treatment groups; Group 1: Conventional table tennis (CTT, N=6) players and Group 2: Longer reach table tennis (LRTT, N=5) players. The players' fitness and skill performances were tested before and after four weeks skill training programme. Both categories of players also competed in three sets of trial matches before and after the training programme, which were video taped and analyzed. During the trial matches, the players' exercise heart rates were measured using Polar heart rate monitors, to assess the intensity of competing on the longer reach and conventional tables. Findings were analyzed using descriptive statistics and t-test. Predicted $\dot{V}O_{2max}$ assessed with the progressive multistage shuttle run test also showed relatively superior improvements in the LRTT players in contrast to the CTT players: 7.2 $ml \cdot kg^{-1} \cdot min^{-1}$ (SE=3.02) (LRTT Group) and 3.1 $ml \cdot kg^{-1} \cdot min^{-1}$ (SE=1.35) (CTT Group). This indicates that the longer reach table tennis was more effective in improving the players' aerobic fitness than conventional table tennis. In order to assess players' ability to apply skills in competitive situation, their performances were analyzed in pre- and post-test trial matches. The match analyses yielded the following results;
LRTT Group: Service had little effects on opponents because of the longer distance it traveled before it was retrieved. This reduced the spin on the ball thereby promoting safer returns and limiting trickery in service delivery. Opponents also had ample time to successfully

retrieve services. Players generally avoided short returns because it was regarded as a fault if the ball landed in the *still waters area* (i.e. the 0.5m extensions in the middle on either sides of the longer reach table). Consequently, short players were not disadvantaged. Rather, players played longer rallies, i.e. aiming at the centre of the table and beyond in order to increase the chances of the ball landing correctly with each rally. In the post-test trial matches, mean exercise heart rate for the LRTT group was 191.6bpm. This was higher than the 181.0bpm found for the same group of players when they competed on conventional tables. The LRTT players also recovered faster 60secs. after competing on the conventional table (28bpm) than they did after playing on the longer reach table (25.6bpm). For the matches analyzed, the average number of rallies per point was 4.5 compared to 2.5 when the LRTT group competed on the CTT. In the post-test period, the total number of points (not games) won by each player in every game (in the LRTT group) over six trial matches was summed. This gave a total of 500 points. Whereas when the same players competed on the CTT two days later the total points won was 464. This gave a decline of 36 points and suggests that rallies of the LRTT players were more consistent on the longer reach table than on the conventional table and that matches played were more keenly contested on the longer reach tables than on conventional tables. Duration of the games on the LRTT ranged from 4-9 minutes, but when the players competed on the CTT the games lasted 3-7minutes.

CTT Group: When the CTT players competed on the longer reach table, some played more consistently, but no consistent trend was noted.

For the matches analyzed, the average number of rallies per point was 2.4 compared to 2.6 when the CTT group competed on the LRTT.

Based on the results of the experiment and in spite of its limitations, it was concluded that the longer reach table tennis was more effective in promoting longer rallies and athletic effort in South African national players. It was recommended that the ITTF should introduce the LRTT as an invitational tournament to test its suitability for TV coverage and public appeal.

(*Key words: longer reach table tennis, rallies, fitness, South African national players*)

1 Introduction

In the early years of table tennis (1920s-1950s), players' skills were most often restricted to the chop or push, smash strokes and block shots. Therefore, players of similar abilities who were able to chop continuously played for longer times than usual and such long delays eventually necessitated the introduction of the expedite rule. It would be interesting however, to find out whether long rallies were appealing to spectators in those days. Those were the formative years of table tennis, when it was popularly referred to as ping-pong. From the 1960s to

date, competitive table tennis has witnessed a phenomenological transformation characterized by the introduction of modern skills, such as the topspin drive and counter smashes and drives. The inclusion of table tennis as an Olympic sport in Seoul, South Korea in 1988 coupled with professionalization of the sport considerably enhanced its status and image worldwide.

In modern competitive table tennis, services have been revolustionized to include a variety of spins. Ball speed and spin are also greatly emphasized by many players. Of major concern to the ITTF is the advancement in rubber technology, which has the potential of 'winning' a game for a player. The impact of technological advances on table tennis is therefore widely conceived as giving players the competitive edge needed for a successful outing. The cumulative effects of these developments are that rallies are now relatively short, the game stands the risk of losing public appeal and players' fitness and athletic effort are compromised. These developments have stimulated worldwide debate on the future of international table tennis (Clemett, 1998).

In January 1999, the ITTF sponsored a conference in Copenhagen, Denmark on "How to make table tennis sport more attractive to TV and spectators." At top-level competition, rallies have been criticized as too short and brisk to the effect that the sport was fast losing public appeal and spectators were often denied the opportunity of enjoying the game and determining how points were lost and won. This conference motivated an initial experiment, which involves a physical expansion of the size of the conventional table. This further stimulated the idea of longer reach table tennis, which involves increasing the length of the table by one meter in the centre, i.e. 0.5m in each half.[1] In order to determine whether the longer-reach table would promote longer rallies and athletic effort in table tennis players, the ITTF commissioned an experiment in September 2000. The following is a report of the ITTF Longer Reach Table Tennis (LRTT) Experiment involving South African national players, carried out from January to March 2001. Specifically, the experiment was carried out to establish the following:

- To determine whether the longer reach table will promote longer rallies.
- To assess the effects of the longer reach table on players' fitness and athletic effort.
- To assess the extent to which the longer reach table will enhance visibility of rallies in a table tennis match.

The LRTT experiment was guided by the following hypotheses:

- South African national players who trained on the longer reach table will demonstrate superior fitness qualities than those who practiced on conventional table tennis tables.
- South African national players who trained on the longer reach table will perform better skills than those who practiced on conventional table tennis tables.
- Playing on the longer-reach table will be more visible to spectators than playing on conventional table.

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[1] A detailed description of the longer reach table is described in the methods section.

1.1 Theoretical analysis

This experiment was based on the following assumptions:

1.1.1 There is a logical relationship between an increase in court size and amount of available playing space. It also logical that a bigger playing surface might reduce the margin of errors committed in stroke production. Therefore, it is assumed that when the table is elongated there is a possibility that players will commit fewer errors and consequently play longer.

1.1.2 Analyses of table tennis matches have commonly agreed that most rallies are played diagonally, i.e. crosscourt because it provides players with longer playing angles and promotes more accurate and consistent stroke delivery. Lengthening the table therefore increases playing angles, both crosscourt and straight court.

The results of the experiment have implications for the ITTF in formulating new policies for table tennis in the new millennium. The results of the experiment may help to improve the image, status and popularity of table tennis as a recreational and competitive sport.

1.2 Limitations

The findings of this experiment should be interpreted in the light of the following unavoidable constraints:

1.2.1 The ITTF longer-reach table tennis experiment involved amateur South African table tennis players, who were not participating in any national training programme at the time of the experiment. The training programme lasted four weeks. Some of the players were students while others were workers. Consequently, they were able to practice for only two hours thrice a week. Longer training sessions would have yielded more positive results.

1.2.2 Four female players and eight males initially participated in the experiment. One of the females was excluded later by the South African Table Tennis Board for disciplinary reasons. The fewer number of women players in the experiment is therefore a reflection of the general difficulty in finding elite female table tennis players in large numbers in the country. Consequently, the data for the training groups were not analyzed based on sex.

1.2.3 In this experiment, 38mm balls were used. It was not feasible to get 40mm balls in sufficient quantity in time for the multiball exercises and training activities.

1.2.4 It was difficult to confirm the reliability of the skill tests. However, the tests were given by experienced table tennis coaches and were judged as satisfactory in reflecting the players' skill performances. Also, the extent of the relationship between the players' correct execution of the skills in the tests and successful application of the skills in a match situation was not examined in the experiment.

1.2.5 This experiment did not involve defensive players (e.g. Japanese type) because no defensive player was available at the time of the experiment. It would have been interesting to find out the effects of the longer reach table on defensive players.

The above limitations should be taken into account in carrying out further tests on the longer reach table tennis.

2 Methods and procedure

2.1 Experimental design

A pretest-posttest-control group design was used in the ITTF Longer Reach Table Tennis Experiment. In this design, players' pre-experiment data were used as control measurements. The South African national players were divided into two groups and exposed to same physical conditioning and skill training programmes for four weeks. In the skill-training programme, one group used the conventional table tennis table (Group 1: CTT category) while the other group practised on the longer-reach table (Group 2: LRTT category). The fitness components and skills of both groups of players were tested before and after the training programme. At the end of the training programme, both groups of players participated in a trial competition, which was video taped and subsequently analysed. Thereafter, both categories swapped tables and re-played the trial matches, i.e. Group 1 competed on the longer reach table while Group 2, which trained on the longer reach table, played on the conventional table. The trial matches were analysed and compared to evaluate the effectiveness or otherwise of the longer reach table tennis in promoting rallies and the players' athletic effort.

2.2 Subjects

A total of 11 South African national players comprising 8 men and 4 women, were involved in the experiment. Based on the recommendations of the national and provincial coaches, they were purposively assigned to two groups as stated above: Group 1 (n = 6: 4 men and 2 women) and Group 2 (n= 5: 4 men and 1 woman). In assigning the players to treatment groups, the following criteria were considered: National ranking/playing ability, age, height and gender. Players' age and height were taken into account in order to evaluate the effects of the longer reach table on short and junior players. National-level players were selected for the experiment because of the need to perform advanced skills consistently.

2.3 Procedure

On obtaining due permission to conduct the experiment form the South African Table Tennis Board, the players to be involved who were all based in the Western Province of South Africa were invited to a briefing meeting held on 22nd January 2001. At the meeting, the purpose and procedure of the experiment were explained to the players who wilfully agreed to participate in the experiment. They all filled and signed an informed consent form and subsequently participated in skill and fitness testing and training sessions for four weeks. The players' generally used Tibhar, Sriver, and Stag rubbers and Stag glue. Two of the players had participated at the world championships and one at the junior Olympics.

2.4 Pilot test

A pilot test, involving the coaches and field workers, was carried out on 26th January 2001. The pilot test was conducted to refine administration procedures for the skill tests, clarify issues and finalize preparations for the fitness testing and skill training programme. In the pilot test, one of the coaches, ALT explained and demonstrated the procedures for the skill testing, which were rehearsed by the coaches and field assistants.

2.5 Venue of the experiment and playing conditions

The ITTF LRTT Experiment took place at two locations in the Western Cape Province of the Republic of South Africa. The fitness testing was done at Discovery Health High Performance Testing Centre, National Sports Science Institute, Newlands, Cape Town. The skill training programme was carried out in a table tennis hall at A.D. Wassenaar Sports Centre, Sanlam headquarters, Belville, Cape Town. The hall had adequate playing space and lighting. During the experiment ambient temperature was measured with 76mm Brannan thermometer (Made in England). This ranged from 23-32°C (Ventilation was poor). Relative humidity ranged between 28% and 33%.

2.6 Description of the longer-reach table and accessories[2]

The table is separated into two halves by an additional distance of one metre (39 inches in imperial units) i.e. 0.5m on each half. The net is fixed in the centre as in the conventional table CTT. All other measurements are the same as for CTT. For visibility purposes, the 0.5m extensions in both halves, bounded by horizontal white lines are sprayed in green colour. This area is named *still waters area* as shown in Figure 1. The other parts of the table are sprayed sky blue as in the CTT. This design was chosen based on the rationale that it would not render useless the millions of table tennis tables all over the world. A conventional table tennis table is easily adaptable to longer reach table because such adaptation involves merely extending each half of the table by 0.5m from the hinge or centre. A conventional (stag) net was used for the experiment. Nittaku and Stag balls were also used.

[2] The design of the longer-reach table tennis is such that conventional table tennis tables could be adapted for longer-reach play because only the length of the table requires expansion. All other measurements are the same as for the conventional table tennis table. The longer reach table was constructed by Mr. Pedro Meyer (Name of table: Pedrollaway).

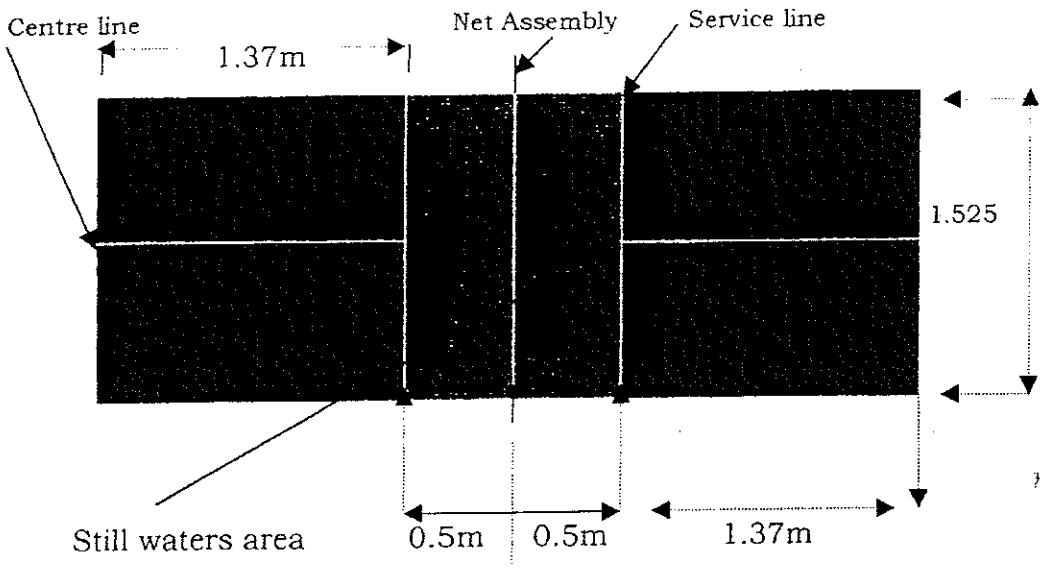

Figure 1. Dimensions of the longer-reach table with suggested labeling (Aerial view).

2.7 Fitness and skill testing

2.7.1 Anthropometry and fitness testing: Two sets of testing were undertaken, i.e. 24hours before and after the experiment. Pre-experiment testing was carried out on 27th January 2001, while the post-test was conducted on 3rd March 2001. The anthropometric and fitness measurements were conducted as follows:

The anthropometric measurements were generally carried out as prescribed by Ross and Marfell-Jones (1991) and Norton and Olds (1996).

- Body Mass — Body mass was measured on a calibrated weighing scale and recorded to the nearest 100 g. Players were weighed in underpants and without shoes, preferably before a large meal.
- Stature — This measurement was recorded as the height from the floor to the vertex of the head. The vertex is defined as the highest point on the skull when an imaginary line between the lower margin of the eye socket and the upper margin of the zygomatic bone is parallel to the ground. The subject stood barefoot with the arms hanging by the sides. The heels, buttocks, upper back and head were in contact with the wall. Prior to measurement the players were instructed to look ahead and take a deep breath. Measurements were recorded to the nearest mm. (Measuring error < 2mm).
- Skinfolds — *Triceps*: Measured from the back on the posterior surface of the arm midway between the top of the shoulder (acromion process) and the elbow (olecranon process). The upper limb hung loosely by the side with the player in a standing position. *Biceps:* Measured from the front on the anterior surface of the arm midway between the top of the shoulder and the elbow. The subject stood in the same position as for the triceps measurement. *Subscapular:* Measured just below the inferior angle of the scapula with the fold in an oblique plane descending laterally (outwards)

and downwards at an angle of approximately 45° to the horizontal. *Supra-iliac:* Measured 5 cm above the iliac crest with the fold oblique, descending medially (inwards) and downwards at an angle of about 45° to the horizontal. The subject stood erect with the upper limbs by the side and the abdominal muscles relaxed. *Calf:* Measured on the medial surface of the calf at the level of the greatest calf circumference. The subject's weight was rested on the other leg. *Thigh:* Measured at the mid-point on the anterior surface of the thigh with the fold parallel to the long axis of the thigh. The subject's weight rested on the other leg so that the knee joint of the measured leg formed an angle of about 120°. *Abdominal:* Measured in a vertical plane 5 cm to the left of the subjects' umbilicus.

- Girth measurements — These measurements were recorded to the nearest cm. The measuring error was less than 1 cm. *Mid-thigh:* Measured at the level at which the thigh skinfold was assessed. Body weight was evenly distributed on both feet. *Forearm:* Measured at the maximal girth of the forearm when the arm was hanging relaxed by the side.
- Derived Measurements — *Body fat:* This was estimated from the sum of seven skinfolds and percent body fat. *Sum of Skinfolds:* This included biceps, triceps, subscapular, suprailiac, abdominal, thigh and medial calf skinfolds. *Percentage of Body Fat:* The Durnin and Womersley's technique should be used to estimate percentage of body fat (Durnin and Womersley, 1974). This is a general ised equation with limited population specificity since it was developed from a heterogeneous group of varying ages (n = 481). This technique does seem to over-estimate percent body fat in physically active individuals who are older than 30 years. Percentage of body fat was calculated from four skinfold sites: triceps, biceps, subscapular and suprailiac. The log of the sum of the four skinfold thicknesses was substituted into one of the following equations:

	Age (yrs)	
Males	17 or less	$D = 1.1533 - (0.0643 \times L)$;
	17 – 19	$D = 1.1620 - (0.0630 \times L)$;
	20 – 29	$D = 1.1631 - (0.0632 \times L)$.
Females	16 or less	$D = 1.1369 - (0.0598 \times L)$;
	16 – 19	$D = 1.1549 - (0.0678 \times L)$;
	20 – 29	$D = 1.1599 - (0.0717 \times L)$;
	30 – 39	$D = 1.1423 - (0.0632 \times L)$.

where, D = predicted density of the body (g/ml) and L = log of the total of the 4 skinfolds (mm). Subsequently, the predicted percent body fat was calculated using Brozek et al.'s (1963) formula: predicted % body fat = 100 (4.570/D – 4.142).

- Muscle mass — The following measurements were used for anthropometric assessment of muscle mass (Martin et al., 1990): stature (cm), mid-thigh, girth (cm), mid-thigh skinfold (mm), calf girth (cm), calf skinfold (cm) and forearm girth (cm). Muscle mass was derived from the following equations as suggested by Martin et al. (1990):

  Muscle mass (g) = $S(0.0553CTG^2 + 0.0987FG^2 + 0.0331CCG^2) - 2445$,

  where; S = stature

CTG = corrected mid-thigh girth
FG = forearm girth
CCG = corrected calf girth
CTG = TG – π(mid-thigh skinfold/10)
CCG = CG – π(calf skinfold/10).

Typical muscle mass values using this technique on males are available (Spenst et al., 1993).

- Flexibility — *Straight leg hamstring test (hip flexion):* The purpose of this test was to measure the player's hamstring flexibility in both limbs. The player lied supine on a bed, while one leg is passively rotated about the hip joint as far as possible with the knee fully extended (Figure 2). One tester lifted the leg and the other tester measured the angle reached using a goniometer. The tester moving the leg needed to place one hand in front, but slightly below the knee and the other at the base of the ankle forcing the leg into full extension prior to lifting the leg (the leg must be kept in full extension throughout the movement). The fulcrum of the goniometer was held over the greater trochanter, while the moving arm was aligned with the midline of the femur using the lateral epicondyle as a reference point. The stationary arm of the goniometer was aligned with the lateral midline of the pelvis (Maud and Cortez-Cooper, 1995). The angle of displacement from the horizontal was measured. The opposite leg was held firmly by a separate tester or by using a strap, so that there was no flexion at the hip joint. The procedure was repeated for both legs. (In athletic population, a hip flexion of greater the 90° is recommended). *Modified Thomas test:* The test is used to obtain measures of flexibility for the iliopsoas and quadriceps (Harvey, 1998). For the modified Thomas test, the subject sits on the end of the plinth. The subject then rolls back on to the plinth and pulls both knees to the chest. This is to ensure that the lumbar spine is flat on the plinth and the pelvis is posteriorly rotated. The subject holds the contra-lateral hip in maximum flexion with the arms, while the limb to be tested is lowered towards the floor (Figure 3). Two angles are measured (using a Goniometer) for each limb: The length of the iliopsoas is determined by measuring the angle of hip flexion.

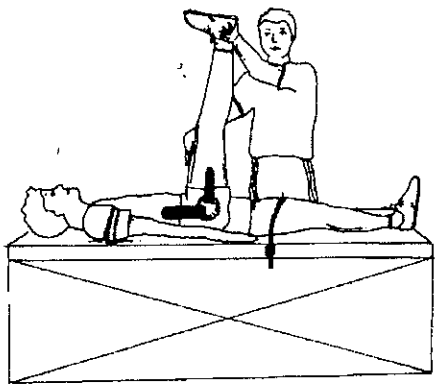

Figure 2. Player and tester positioning for the straight leg hamstring test.

The stationary arm of the goniometer is aligned with the lateral midline of the pelvis. The moving arm is aligned with the midline of the femur using the lateral epicondyle as a reference point (Figure 4a). The length of the quadriceps is determined by measuring the knee flexion angle. The stationary arm of the goniometer is aligned with the lateral midline of the thigh, using the greater trochanter as a reference point. The fulcrum is placed over the lateral epicondyle of the femur. The moving arm is aligned with the lateral midline of the fibula, using the lateral malleolus as a reference point (Figure 4b).

Figure 3. Body position for the modified Thomas test

Figure 4a. Flexibility – Illiopsoas

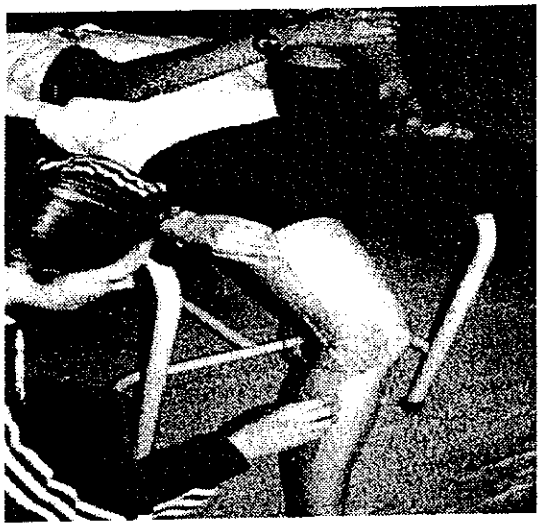

Figure 4b. Flexibility – Rectus femoris

- Internal end external shoulder rotation – The athlete is supine with the arm abducted to 90°, the elbow flexed to 90° and the forearm pronated perpendicular to the table (Maud and Cortez-Cooper, 1995). The moving arm of the goniometer is aligned along the ulna using the styloid process as the reference point. The fulcrum is placed over the olecranon, between the medial and lateral epicondyles of the humerus. The stationary arm of the goniometer is placed perpendicular to the ground but pointing downwards. External rotation is recorded as the maximal movement of the forearm from the upright, in neutral position to a position of full backward rotation. Internal rotation is from neutral towards a forwardly, rotated position. The subject's back and shoulder must not lose contact with the plinth during the test (Maud and Cortez- Cooper, 1995).
- Eye-hand co-ordination/reaction time – An electronic board called the Sports Vision Trainer (SVT), consisting of 80 lights is mounted on a wall. A player responds by 'touching' the lights which flicker on the SVT with his/her hand in a confined area on the board. The time span between the lights showing is 0.50 of a second. The lights have been randomly programmed to flicker 30times (for 15seconds each trial), thus meeting the needs of table tennis players. The SVT is connected to a computer, which measures the player's initial visual reaction time and corresponding eye-hand co-ordination denoted as a percentage of the number of lights the player touches in 15 seconds. A score denoting the % correct 'touches' is automatically displayed on the computer and stored. Players were given 3 trials and the average score taken.
- Muscle strength, power and endurance – *Strength:* The one repetition maximum test (1RM) test was used to determine the subject's maximal strength. These values are useful for prescribing correct loads in exercise programmes and for evaluating strength improvements over time. For the upper body, the bench press was used for testing maximal strength, while leg press was used for assessing lower body strength. *Testing procedure to*

obtain a one-repetition maximum: A light warm up of 5 – 10 repetitions at 40% of estimated maximum. After a 2 min. rest with light stretching, progressively increase the weight going from 60 – 80%, using 3 - 5 repetitions to accomplish this. Step 2 will take the individual close to their 1RM. Allow them again to rest for 2 min prior to increasing the weight. After each 1RM attempt, allow the individual 3 – 5 min rest until a failed attempt occurs. A 1RM value is reported as the weight of the last successfully completed lift (Kraemer and Fry, 1995). *Bench Press:* For this exercise, the subject lies supine on a bench with the feet flat on the floor and the hips and shoulders in contact with the bench. An Olympic bar is gripped 5–10 cm wider than shoulder width, so that when the bar is placed on the chest, the elbow joints are flexed to approximately 90°. The subjects commence this lift by lowering the bar, under control, to the centre of the chest, touching the chest lightly (no bouncing the bar on the chest) and then extending upwards until the arms are in a fully locked position. The subject is advised to inhale when lowering the weight and exhale when pressing it. Criteria for disqualifying a lift include: lifting the buttocks during the movement, bouncing the bar off the chest, uneven extension of the arms and any touching of the bar by the spotter. *Incline Leg Press:* The position of the feet on plate can be standardised by marking two positions on the foot plate: Two-foot positions are indicated by drawing a line 5 cm from the top of the plate (majority of subjects should reach this line). A second line may be drawn across the middle of plate (for those subjects who cannot comfortably reach the top line). The foot position should be recorded to ensure reliable re-testing. Determining level to which plate is to be lowered: The plate should be lowered to the point where a 90° angle is formed at the knee joint. The height of the footplate along its pulley rail is then measured from the base of the pulley rail. This measurement is recorded such that there is standardisation when the subject is re-tested (to ensure the subject descends to the exact knee angle on the second testing session).

- Strength Endurance – *Push up (1 minute):* Male subjects assume a position where their hands are placed on the floor with thumbs shoulder width apart. Keeping the back and body straight, subjects lower their upper bodies to the testers fist, placed below the sternum and ascend until elbows are fully extended (straightened). If subjects do not adhere to these specifications the repetition is not counted. Female subjects perform a modified push-up from their knees. Their backs are kept flat and hands are placed so that the thumbs are shoulder width apart. The number of push-ups performed in one minute is recorded. Subjects may rest within the one-minute period.
- Hand Grip Strength – The purpose of this test is to measure the isometric grip strength of the hand. The subject stands with the arm extended (next to the leg) and then proceed to squeeze the dynamometer as vigorously as possible. The hand holding the dynamometer is not allowed to touch the body, while the test is being administered. The subject is allowed two attempts with at least 4 min between trials.
- Leg Power – *Vertical jump:* The purpose of this test is to measure the subject's instantaneous explosive leg power. The subject stands, in athletic

shoes, with his right side (hip) against a wall, onto which is mounted a calibrated measuring board. The subject then reaches with the right hand to touch the board at the highest point possible (heels of the feet stay on the ground). This point is recorded as "standing height". The subject then places chalk on his fingertips (dominant hand) and then, from a two-footed take-off position the subject flexes at the hip and knee joints and using his arms as momentum attempts to extend as high as possible. At the top of the jump the subject touches and marks the board with his fingertips. The score for the jump is the difference between the standing height and the jump height. The highest of three separate trials is recorded as the subject's maximum score. It should be noted that if the subject takes any form of step or shuffle prior to the jump, the score is rendered invalid.

- Table Tennis Agility Test – The purpose of the test is to measure the players' movement time and agility. The test is set up as follows:

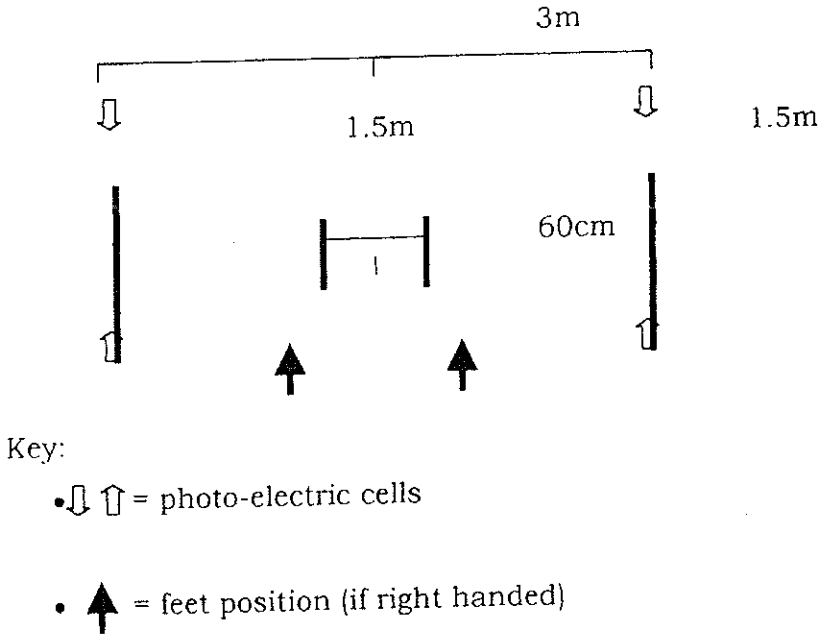

Figure 5. Diagram for the table tennis agility test.

In giving this test, two photo-electric cells are set up 3 metres apart with the starter cells on the right side. 2 lines are made 60cm apart, directly in the middle of the 2 photo-electric cell sets set up 3m apart. The player stands with his/her feet either side of the 2 lines 60cm apart (see figure), holding a bat in his/her right/left hand. A right-handed player stands with the starting photo-electric cell set to his/her right hand side. The player holds a table tennis bat in his/her left hand. Feet are either side of the 2 lines that are 60cm apart. The player then shuffles to his/her right and breaks the beam with a forehand stroke. This is followed directly after by a shuffle to the left where the second beam is broken by the right hand with a backhand stroke. A left-handed player stands so that the starting photo electric cell set are to his/her left. The player holds a table tennis bat in his/her left hand. The test is started by shuffling to the left and breaking the beam of the first set of

cells. The player then shuffles back to his /her right and breaks the beam of the second set of cells with a backhand stroke. A player is allowed two warm up attempts. These are to be done sub- maximally. The better of two maximum trials is recorded.

- Flamingo balance test — This test entails balancing on one leg on a balance beam of set dimensions. Equipment used included metal beam 50cm long, 4cm high and 3cm wide, covered with a material (max thickness: 5mm) securely fastened to the beam. Two supports 15cm long and 2cm wide provided stability. One stopwatch (with automatic reset or zero setting so that it continues after stopping and a subsequent restart) was used per beam. The subject is required to stay balanced as long as possible on the long axis of the beam while standing on his/her preferred foot. The free leg is bent backwards and the foot is gripped by the subject's hand on the same side, standing like a flamingo. The other arm is used to maintain balance. The tester helps to place the subject into the correct position by supporting with his/her forearm. A player is allowed one practice trial and the test begins as soon as the subject releases the tester's supporting arm in the second trial. The subject tries to keep balanced in this position for one minute. Each time the subject loses balance (i.e. when (s)he lets go of the free leg, or touches the ground with any part of his/her body, the test stops. After each such fall, the same procedure starts all over again until one full minute has elapsed. A fall is determined when the subject loses balance by releasing his/her free leg or when he/she touches the ground with any part of the body. The number of attempts (not falls) needed to keep in balance on the beam for one minute. For example, should a subject require 5 attempts to keep in balance for one minute, he/she scores 5. Note: If the subject loses balance 15 times within the first 30 seconds, the test is ended and the subject is awarded a zero score.
- Multistage shuttle run — The maximal aerobic power (endurance fitness) of players can be assessed by a progressive multistage shuttle run test according to the protocol of Lèger et al. (1988). This test has both excellent test - retest reliability ($r = 0.97$) and validity ($r = 0.84$) (Lèger and Lambert, 1982). For this maximal test, mark out two lines on a level playing field or gymnasium 20m apart. Subjects run back and forth on this 20m straight course touching the 20m-line with one foot at the precise moment that a sound signal is emitted from the audiocassette. The frequency of the sound signal increases in such a way that running speed is increased by 0.5 km/hr each minute, from an initial running speed of 8.5 km/hr. As the subject runs the audiocassette informs the tester at which level and shuttle the subject is on. There are between 9 and 16 shuttles per level. A new version of the tape simply counts the total number of shuttles. No warm up is necessary for this test. Subjects may not run wide circles. Each subject must place one foot just over the line and then turn immediately to face the opposite direction. Subjects must receive two warnings for not reaching the line at the time of the auditory signal. On the third warning, the test is ended. The score is taken as the last shuttle where the subject's foot crossed the line prior to, or

at the same time as the signal. In order to convert the total number of shuttle run to $\dot{V}O_{2max}$, a reference table is used (Lèger and Lambert, 1982).

2.7.2 Skill and tactical testing: The skill and tactical tests used in this experiment were adapted from those recommended for national level players by the English Table Tennis Association (1995) (As published by Toriola, SISA, 1999). The tests were carried out by two players in succession, i.e. a controller or feeder acted as a sparring partner to the testee, after which they swapped roles and the testee played the role of the feeder. In cases where feeders could not control the ball accurately, the tests were given using multiballs. In order to achieve reliable results, the tests were given by table tennis coaches who are well versed in the techniques of the game. As stated in the limitations of this experiment, the tests are suited to attacking style of play. The players' skills were tested before and after the experiment. Specifically, the pre- and post-skill tests were conducted on 28th January 2001 and 23rd February 2001. Specifically, the tests included the following skills and tactics: Service: Service accuracy to designated service areas on the table given 20 trials assessed out of a maximum score of 100; Service return: Quality of service return judged on a 20-point scale; Counter hit drive: The number of successful drives in 5trials (Maximum = 120); Topspin drive: Number of successfully executed drives in 5trials (Maximum = 80drives); Topspin drive with footwork: Alternate forehand topspins from forehand (FH) and back hand (BH) positions (Maximum = 60 combinations); Third ball attack: Quality of attack from 10 trials rated on 100 point scale; Backhand and forehand drives: Combined FH and BH topspin drives directed to alternate FH and BH sides. It was judged on a 60 combination of drives scale; Combination of topspin drive and smash: From a 10-trial sequence rated on 100 point scale, the player topspins to the BH side and smashes down the line to the FH side; Counter topspin drives: Players topspin against topspins played diagonally to the FH sides. Five trials were allowed and performances rated on a 60point scale; Smash: Players smash 20 lobs and are assessed on the number of successful smashes; and block shot: Player blocks topspin drives directed to either FH or BH sides. Five trials were allowed and the number of successful blocks rated on 100point scale.

2.7.3 Trial Matches: In order to evaluate the extent to which the longer-reach table could promote long rallies, the players participated in two sets of trial matches before and after the training programme. The trial competitions were carried out on round robin basis and decided on best of three sets in each of the training groups, i.e. LRTT and CTT. The trial matches were video taped in order to facilitate post-match analysis of rallies played in the games. Analysis of the matches played on both CTT and LRTT is presented in Part Three of this report. In the trial matches, it was considered a fault if the ball landed anywhere in the still waters area painted green (See Figure 1). A ball, which lands on the service line either during service or rally was regarded as a valid delivery.

2.8 Skill Training Programme[3]

Both groups undertook 4 weeks training programme, which was carried out by CM (the South African national table tennis coach), GN (Western Province coach) and ALT (a former national player and coach). All the players attended at least 90% of the training sessions, which took place thrice a week. The following were the basic features of the training programme:

- Physical conditioning: Stretching and conditioning exercises aimed at promoting fitness, strength and flexibility.
- Skill training: Service and service return, topspin drive, smash, block shot, counter drives and smash.
- Tactical training: Third-ball attack, combination of drives and smash, and variation in positional and directional play.

The training programme was designed logically to achieve the following objectives:

2.8.1 Skill and footwork development

2.8.2 Fitness development

2.8.3 Development of tactics

2.8.4 Psychological preparation

Each training session lasted at least two hours. For all testing and training sessions, Double Fish three-star, Stag and Tibhar basic balls were used.

2.8.5 Exercise heart rate monitoring: During the skill tests, trial matches and training programme, the players' exercise heart rates (EHR) were periodically measured. Players wore the HR watches (Model CE 0537, Manufactured by Polar Electro Company, Finland) around their non-dominant wrists and Polar electronic sensors designed to pick up heart beat signals were worn around their chests. Shortly before the players wore the strap a thin film of Signa electrode gel (Parker Laboratories, Inc., Orange, New Jersey 07050, U.S.A.) was applied on the sensor. The Signa electrode gel is a non-irritating chemical, which facilitates conduction between the skin and electrodes. EHR monitoring was carried out to crosscheck the intensities of the testing and training activities in the longer reach and conventional table tennis groups. Another purpose of the EHR measurement was to compare the effects of the longer reach and conventional tables on the players' fitness levels. EHR data were downloaded via Polar advisor software and Polar advantage computer interface.

2.8.6 Motivation of players: In order to ensure that the players and coaches participated regularly in the training and testing sessions and to sustain their interest in the experiment, they were remunerated. The players were also promised that their involvement in the experiment would improve their skills and playing abilities. The players and coaches were further assured that their names would be included in the report of the experiment to be submitted to the ITTF.

2.8.7 Refreshment: During the experiment the players were served Game, an isotonic sports drink manufactured by Bromor Foods (Pty) Ltd., 5 Sunrise Circle,

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[3] **Rationale for Exercises in Training Programme:** Activities in the training programme were selected based on the need to sharpen players' skills and tactics in view of the limited time available for the experiment. Exercises in the training programme were organised in ascending order of difficulty such that the activities taper off towards trial competition at the end of the experiment. A sample copy of the skill and tactical training programme is available on request.

Maitland 7045, South Africa. This sports drink facilitated rapid absorption of vitamins, minerals, salts and carbohydrates lost during physical exertion. Contents of the sports drinks as stated on the pack were as follows: Sugar (Sucrose), glucose, maltodextrin, acidifying agent, sodium phosphate, calcium lactate, flavourant, anti-caking agent, vitamin C, socium chloride, sodium citrate, potassium chloride, acesulfame K (non-nutritive sweetner), beta carotene, colourants, vitamin E, vitamin B6 and folic acid. Nutritional information of the Game sports drink per 20g or 250ml serving is provided in Table 1.

Table 1. Nutritional information on game sports drink per 20g or 250ml serving to S.A players.

Minerals		Per serving	% RDA per serving	Per 100ml
ENERGY	kj	305	N/A	122
CARBOHYDRATES	g	19	N/A	7.6
SODIUM	mg	63	N/A	25
VITAMIN A	µg R.E.	21	2	
VITAMIN E	mg α T.E.	1.3	13	
VITAMIN C	mg	70	117	
VITAMIN B6	mg	0.5	25	
FOLIC ACID	mg	50	25	
CALCIUM	mg	26	3	
PHOSPHORUS	mg	38	5	
POTASSIUM	mg	13	N/A	

R.E. = Retinol equivalent. T.E. = α Tocopherol equivalent
*RDA for adults and children over 10 years

3 Data analyses

The results were analysed using descriptive statistics, such as means and standard deviations. In order to test the hypotheses developed for the experiment, measurements for Groups 1 and 2 were compared using a series of paired t-test. A probability level of ≤ 0.05 was taken to indicate statistical significance.

Table 2. Summary of South African table tennis players' anthropometric data (Mean±SD) (N=11)

Category	Variable	Pre-Test	Post-Test	t-value	2-tailed sig.
[a]LRTT/ CTT	[b]Age (yrs)	23.8±6.1 17.7±3.5	- -	- -	- -
	Body weight (kg)	73.0±10.7 58.2±11.7	71.9±9.6 58.5±11.5	1.62 0.52	0.18NS[c] 0.63NS
	Sum of SF (mm)	84.3±30.4 60.1±23.1	81.4±28.1 63.6±24.8	0.78 0.19	0.48NS 0.86NS
	%Muscle	51.0±5.5 48.8±4.5	48.2±3.0 48.1±4.5	1.20 1.50	0.30NS 0.20NS
	%Fat	18.6±6.6 15.0±7.0	18.0±6.5 14.8±7.1	1.11 0.57	0.33NS 0.60NS
	[b]Arm span (cm)	182.6±4.0 175.9±15.2	-	-	-

[a]LRTT=Longer Reach Table Tennis Group/CTT=Conventional Table Tennis Group: Values in lower lines are for the CTT group; [b]Only pre-test data were obtained; SF=Skinfolds; [c]NS=Not significant.

4 Results and discussion

4.1 Results of fitness testing

4.1.1 Pre- versus post-experiment: As shown in table 2, the LRTT players lost a mean weight of 1.1kg as compared to the CTT category, which lost 0.2kg. For the LRTT group, the highest weight loss was 3.0kg. In the CTT group, the highest weight loss was 0.9kg. Mean reductions in sum of skinfold were 2.9mm (LRTT Group) and 0.4mm (CTT Group). Data on % muscle mass did not yield a consistent trend. The fitness characteristics of the LRTT group are summarised in Table 3a. Marked pre- and post-experiment improvements in the players' internal and external shoulder rotation, leg power and grip strength (right hand) were found.

Table 3a. Summary of South African table tennis players' fitness data (Mean±SD). (LRTT Group: N=5)[a]

Variable	Pre-Test	Post-Test	t-value	2-tailed sig.
Flexibility (degrees):				
Hamstrings (L)	83.0±11.0	83.0±11.7	0.00	1.00NS[c]
(R)	82.8±15.8	85.2±11.6	0.36	0.74NS
Hip joints (L)	-2.2±7.6	-3.0±3.1	0.27	0.80NS
(R)	-6.00±6.0	-3.2±1.6	1.25	0.28NS
Quadriceps (L)	63.2±9.3	59.6±8.3	0.74	0.50NS
(R)	61.6±3.5	59.6±9.2	0.51	0.64NS
Shoulder joint:				
(Internal rotation)				
(L)	65.6±13.9	56.0±21.9	2:32	0.08NS
(R)	49.6±20.5	48.0±16.4	0.58	0.59NS
(External rotation)				
(L)	79.8±6.5	83.6±8.5	1.10	0.33NS
(R)	83.8±9.3	87.2±7.0	1.43	0.23NS
Running Speed (secs.):				
5m	1.04±0.09	1.05±0.01	0.29	0.79NS
10m	1.78±0.1	1.83±0.1	1.05	0.35NS
Agility (secs.)	0.68±0.01	0.65±0.01	0.97	0.39NS
Leg power (W)	1083.1±158.7	1107.9±163.1	2.16	0.97NS
[b]1RM Bench. press (kg)	56.8±7.5	56.8±7.5	-	-[§]
[b]1RM Leg press (kg.)	190.0±20.0	195.0±25.2	1.00	0.39NS
Grip Strength (kg.)				
(L)	41.3±2.3	39.7±2.7	1.22	0.29NS
(R)	44.8±3.8	42.6±3.3	2.81	0.05*
Push Up (No./min)	26.6±13.3	29.6±13.8	2.54	0.06NS
Balance (Errors/60secs)	3.8±2.4	5.0±3.7	0.71	0.52NS
[c]VO_2max. ($ml.kg.min^{-1}$)	43.4±9.7	50.6±8.5	2.39	0.10NS
HRmax. (bpm)	203.2±15.8	199.8±10.6	1.11	0.35NS

[a]Results are for LRTT (Longer Reach Table Tennis) group (N=5); [b]Data are reported for male players only; [c]NS=Not significant; *P<0.05; HRmax=Maximum heart rate; bpm=Beats per minute; MSR= Multistage shuttle run; [§]t-test was not computed because the standard error of difference was zero; [c]Maximum oxygen uptake.

These amounted to 9.6° and 1.6° for left and right shoulders (internal rotation) and 3.8° and 3.4°, (external rotation), respectively. Corresponding data for the CTT group were: Internal rotation (Left shoulder: 6.7°; right shoulder: 4.3°) and external rotation, (Left shoulder: 2.8°, right shoulder: 0.2°) (Table 3b). These comparisons were however, not statistically significant.

Findings on leg power yielded a mean difference of 24.9W in favour of the LRTT training group. In order to assess the influence of playing on both the

LRTT and CTT tables on the players' fitness levels, the players' aerobic capacities ($\dot{V}O_{2max}$) were predicted from the Progressive Multistage Shuttle run test data. Results also showed relatively superior improvements in the LRTT players in contrast to the CTT players: 7.2 $ml \cdot kg^{-1} \cdot min^{-1}$ (LRTT Group) and 3.1 $ml \cdot kg^{-1} \cdot min^{-1}$ (CTT Group). This indicates that practising and competing on the longer reach table tennis table was more effective in improving the players' aerobic fitness than conventional table tennis. Details on these findings are provided in tables 3a and 3b as well as illustrated in Figures 3-5.

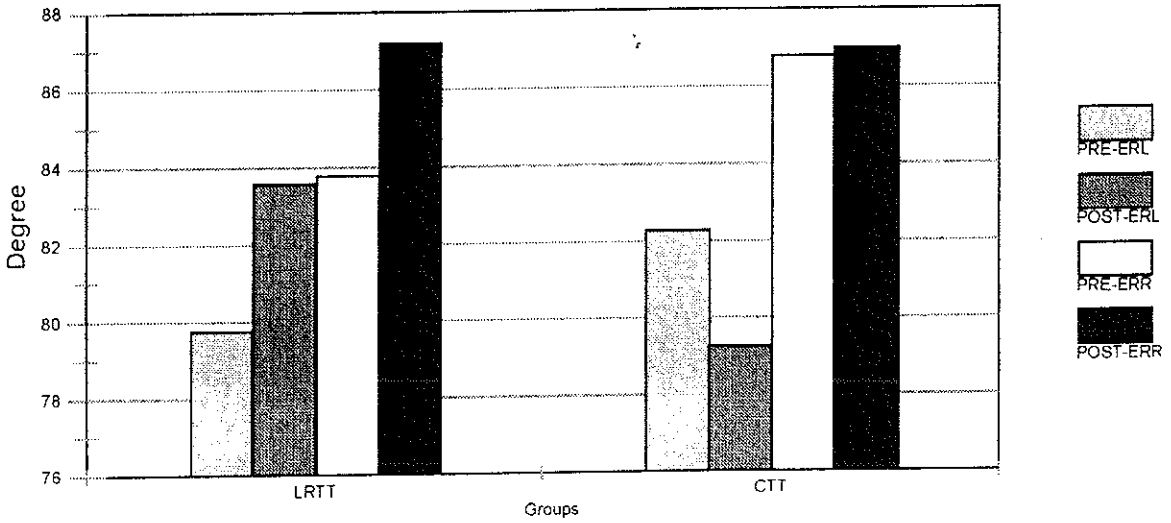

Figure 6. External rotation of left and right shoulder joints.

As illustrated in Figure 6, the least improvement in external shoulder rotation was found in the left shoulder of the CTT players. The highest increase in external rotation was noted in the right shoulder of the LRTT players. Results on leg power showed that the LRTT players had more substantial improvement than the CTT players, whose performances declined after the experiment.

Findings on arm-eye coordination/reaction time measured with the Sport Vision Test (SVT) did not show substantial differences between the LRTT and CTT groups. Mean reaction time for the LRTT and CTT were 65.8% and 65%, respectively. Specifically, these ranged from 45-82% (LRTT) and 27-77% (CTT).

Results on hand grip strength illustrated in Figure 7 showed a similar trend in which the CTT players had superior improvements than the LRTT category.

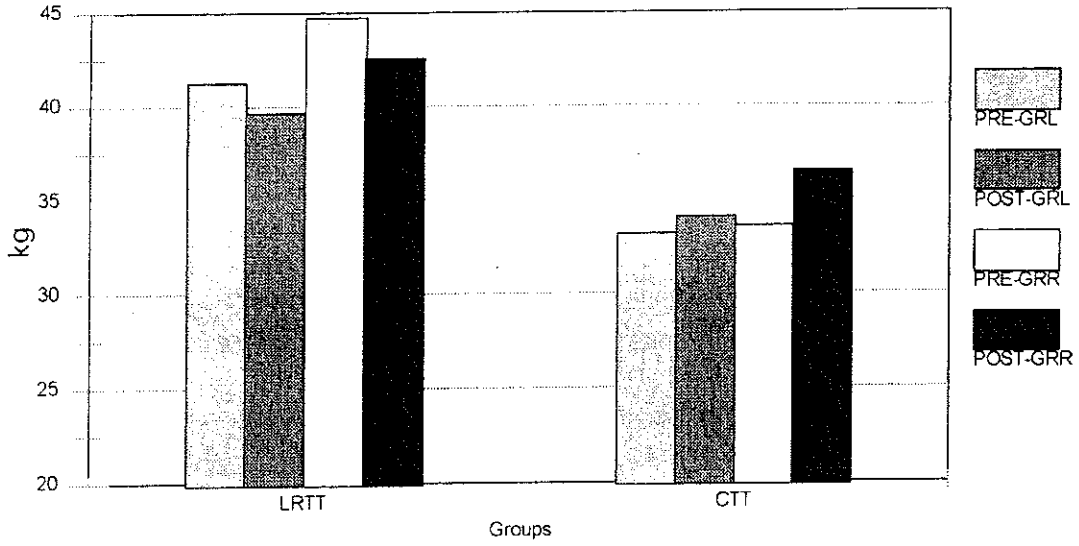

Figure 7. Grip strength (Left and right hands)

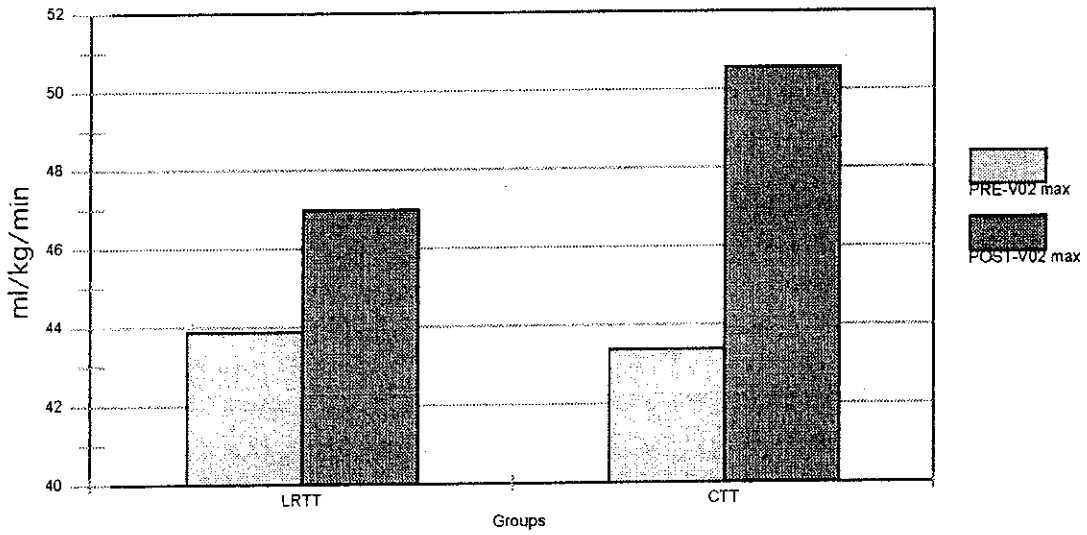

Figure 8. Predicted $\dot{V}O_{2max}$

As stated earlier, the players participated in the Multistage fitness test before and after the experiment. This was intended to determine their maximal heart rates using Polar heart rate monitors. The players' maximum heart rates were subsequently converted to maximum oxygen uptake values ($\dot{V}O_{2max}$) using the table of predicted maximum uptake values for the multistage fitness test as recommended by Brewer et al. (1988) and Leger and Lambert (1982). In the conversion, each player's number of shuttle was compared with predicted $\dot{V}O_{2max}$ Predicted $\dot{V}O_{2max}$ for the pre- and post-experiment measurements are illustrated in Figure 8.

Table 3b. Summary of South African table tennis players' fitness data (Mean±SD) (CTT Group: N=6).

Category	Variable	Pre-Test	Post-Test	t-value	2-tailed sig.
CTT	Flexibility (degrees):				
	Hamstrings (L)	86.8±14.1	83.5±14.	0.82	0.45NS[a]
	(R)	91.0±15.4	88.8±8.4	0.60	0.58NS
	Hip joints (L)	-1.7±6.9	-3.2±4.8	0.17	0.30NS
	(R)	-2.8±5.7	-4.3±5.7	1.51	0.19NS
	Quadriceps (L)	61.3±13.3	56.5±11.5	1.50	0.20NS
	(R)	58.8±12.4	57.0±7.5	0.47	0.65NS
	Shoulder joint: (Internal rotation)				
	(L)	56.8±23.8	50.2±21.1	1.54	0.18NS
	(R)	47.8±15.6	43.5±17.4	1.11	0.32NS
	(External rotation)				
	(L)	82.28±11.3	79.3±19.1	0.67	0.53NS
	(R)	86.8±8.4	87.0±11.7	0.04	0.97NS
	Running Speed (secs.):				
	5m	1.08±0.09	1.12±0.12	1.24	0.27NS
	10m	1.86±0.14	1.92±0.19	0.94	0.39NS
	Agility (secs.)	0.81±0.19	0.75±0.14	1.94	0.11NS
	Leg power (W)	877.5±207.2	868.5±7194.5	0.68	0.53NS
	[b]1RM Bench press (kg.)	55.5±21.0	56.8±20.5	1.00	0.39NS
	[b]1RM Leg press (kg.)	180.0±81.6	195.0±79.0	3.00	0.06NS
	Grip Strength (kg.)				
	(L)	33.2±12.9	34.1±11.0	0.71	0.51NS
	(R)	33.6±10.7	36.5±11.8	1.52	0.19NS
	Push Up (No./min)	26.3±10.4	27.5±8.6	0.46	0.66NS
	Balance (Errors/60secs)	5.8±6.8	8.2±9.3	0.78	0.47NS
	[c]VO_2max. ($ml.kg.min^{-1}$)	43.9±8.8	47.0±8.9	2.26	0.07NS
	HRmax. (bpm)	200.3±12.5	202.2±10.8	1.25	0.27NS

[a]NS = Not significant; [b]Data are reported for male players only; Hrmax = Maximum heart rate; bpm = Beats per min; MSR = Multistage shuttle run; [c]Maximum oxygen uptake.

As shown in Figure 8, the LRTT players had better improvement in $\dot{V}O_{2max}$ than the CTT category. Among the LRTT group $\dot{V}O_{2max}$ values for the pre- and post-experiment measurements ranged from 35.7 $ml \cdot kg^{-1} \cdot min^{-1}$ to 56.5 $ml \cdot kg^{-1} \cdot min^{-1}$ and 39.9 $ml \cdot kg^{-1} \cdot min^{-1}$ to 60.6 $ml \cdot kg^{-1} \cdot min^{-1}$ The post-test values are

comparable to those reported for male Australian players (Allen, 1991). Corresponding values for the CTT group were: Pre-test, from 31.8 $ml \cdot kg^{-1} \cdot min^{-1}$ to 54.3 $ml \cdot kg^{-1} \cdot min^{-1}$ and Post-test: from 33.6 $ml \cdot kg^{-1} \cdot min^{-1}$ to 58.2 $ml \cdot kg^{-1} \cdot min^{-1}$ The improvements noted would have been more substantial if the experiment was carried out over a longer period.

4.2 Results of skill and tactical testing

4.2.1 Pre- versus post-experiment: In general, both groups of players performed better in the skill tests carried out after the training programme than in the pre-experiment testing. In the LRTT group, the most substantial improvement was found regarding forehand (FH) topspin with footwork. The players' poorest performances were in third-ball attack, return of service, combination of FH topspin and smash, counter topspin and block shot. Based on the players' weaknesses after the pre-test skill assessment they were advised on the need to strengthen these weaknesses and exercises included in the training programme were modified to address the shortcomings.

Table 4. Analysis of the total number of points won in two sets of trial matches by the LRTT Group[a]

Players' Initials	Matches played on longer reach table by LRTT group				Matches played on conventional table by LRTT group			
	Game 1	Game 2	Game 3	Row Totals	Game 1	Game 2	Game 3	Row Totals
1. SO/JM	18-21	15-21	-	75	19-21	20-22	-	82
2. KP/JM	17-21	21-14	11-21	105	21-14	16-21	21-11	104
3. SJ/MO	21-15	21-13	-	70	21-17	21-7	-	66
4. KP/MO	12-21	24-22	21-19	119	21-16	21-14	-	72
5. KP/SJ	14-21	14-21	-	70	18-21	15-21	-	75
6. SO/MO	5-21	14-21	-	61	10-21	13-21	-	65
Column Totals	207	221	72	**500pts**	220	212	32	**464pts**

[a]SO = Surita Odendaal; KP = Kurt Petersen; SJ = Shaun Jones; MO = Matthew Overett and JM = Jermaine Mostert.

4.3 Results of trial matches and match analysis

4.3.1 Pre- versus post-experiment: In order to assess players' ability to apply skills in competitive situation, their performances were analysed in pre- and post-test trial matches. The match analyses yielded the following results:

LRTT Group:

- Service had little effect on opponents because of the longer distance the ball travelled before it was retrieved. This reduced the spin in service thereby promoting safer returns and limiting trickery in service delivery. Opponents also had ample time to successfully retrieve services.
- Players played longer rallies, i.e. aimed at the centre of the table and beyond in order to increase the chances of the ball landing correctly with each rally. Short returns were generally avoided because it was regarded as a fault if the ball landed in the still waters area (See Figure 1). Consequently, short players were not disadvantaged. The players were of varying heights and our analyses did not show that height was a major setback.
- Players tended to direct shots to the sides (diagonally) rather than playing straight court. This was an attempt to keep the ball in play as safely as possible. The fact that the rallies were longer made the strokes more visible.
- The LRTT encouraged players to be more centrally placed during a match and this promoted the development of all round play.
- The players generally relied on skill and tactics to win points rather than on their racket covering or glue. This promoted athletic effort in the LRTT group.
- There was a preponderance of forehand topspins and smashes in most of the trial matches played.
- When the LRTT group competed on the conventional table several unforced errors were observed in which some of the players top-spinned beyond the baseline. Many of these strokes would have landed correctly if they were playing on the longer reach table.
- In the post-test trial matches, mean exercise heart rate for the LRTT group was 191.6bpm. This was higher than the 181.0bpm found for the same group of players when they competed on conventional tables. The LRTT players also recovered faster after competing on the conventional table (28bpm) than they did after playing on the longer reach table (25.6bpm). These findings confirmed that the LRTT group did more physical work when competing on the longer reach table than the conventional table.
- For the matches analysed, the average number of rallies per point was 4.2 compared to 2.5 when the LRTT group competed on the CTT. In the post-test period, the total number of points (not games) won by each player in every game (in the LRTT group) over six trial matches was summed. This gave a total of 500 points. Whereas when the same players competed on the CTT two days later the total points won were 464. This gave a decline of 36 points and suggests that rallies of the LRTT players were more consistent on the longer reach table than on the

conventional table and that competition was more keenly contested on the longer reach tables than on conventional tables. Duration of the games on the LRTT ranged from 4-9 minutes, but when the players competed on the CTT the games lasted 3-7minutes. Results of this analysis are presented in table 4.

4.3.1.1 Uniqueness of the longer reach table

4.3.1.1.1 The LRTT could reduce ball speed due to the longer distance the ball has to travel in its trajectory. This will give players ample time to retrieve shots from opposing sides and could potentially promote longer rallies.

4.3.1.1.2 The LRTT reduces effects of spin in service delivery thereby reducing trickery.

4.3.1.1.3 Short balls have little impact on play, because players avoided the still waters area and played longer rallies. Consequently, short players were not disadvantaged.

4.3.1.1.4 The longer reach table imposes new demands on players which could change the pattern of modern table tennis and playing tactics.

4.4 Hypothesis testing

Three hypotheses developed at the start of the experiment were tested as follows:

4.4.1 That South African national players who trained on the longer reach table will demonstrate superior fitness qualities (anthropometric profile, aerobic and anaerobic power, muscular strength and endurance, flexibility, balance, reaction time and speed) than those who practised on conventional table tennis tables. To a large extent this hypothesis was supported because the LRTT players surpassed their CTT counterparts in certain anthropometric (Body weight and fat reduction) and fitness (increase in aerobic power and exercise heart rates) measurements.

4.4.2 That South African national players who practised on the longer reach table will perform better skills (service and return of service, counter hit and top-spin drives, topspin with footwork, smash, block shots) and tactical abilities (third-ball attack, skill combinations, variations in positional and directional play) than those who practised on conventional table tennis tables. This hypothesis was partially accepted because both the LRTT and CTT groups showed marked improvements in backhand counter hit drive and topspin drive with footwork after the training programme. The LRTT group had significantly better improvement in topspin with side-to-side footwork than the CTT category.

4.4.3 That playing on the longer-reach table will be more visible to spectators than playing on conventional table. Except that the longer reach table promoted longer rallies, it was difficult to confirm its public appeal. Further tests are needed in this regard.

4.5 Implications of the findings for the future of table tennis

It is envisaged that the results of the experiment would have the following impact on the future of table tennis if the longer reach table tennis is eventually introduced by the ITTF:

4.5.1 Players would place more emphasis on skill and fitness than trickery and over-reliance on rubber technology.

4.5.2 Players would more frequently use topspins and smashes, which are potentially more appealing to spectators.

4.5.3 The longer-reach table would promote innovations in skill performance and competition tactics.

4.5.4 The longer reach table tennis would necessitate slight modifications in existing rules.

4.5.5 Emphasis would be on playing the ball long toward the baseline and using the side angles.

4.5.6 Service spin would be de-emphasised since the ball would travel through greater distances and it would become progressively loose on the receiver's end, thus compelling players to rely more on skills and athletic effort.

4.5.7 Return of service would be enhanced because of the fewer errors committed in retrieving service.

4.6 Feedback from players

At the end of the experiment, players provided feedback summarised as follows: Three out of 11 players preferred the longer table for the following reasons, " It makes my game more effective; the rallies are longer, you have got to hit the ball more and it is fun; and it permits longer rallies and I can hit harder. One player preferred the longer table because she has been training on it for the past month, but would opt for the conventional table on the long run." Typical criticisms against the longer table from nine players were as follows: "I can use more variety of shots on the normal table; the normal table is dependent on speed and short rallies with winning strokes; the long board encourages more rallies and it is more physically demanding; more strength is required in playing on the long table, it tires you out quicker and longer strokes are frequently used; it is a little difficult to get used to the longer table but it is alright and I can play my strokes good on the longer table but because I cannot topspin I prefer to play on the normal table."

The players' views generally confirm the notion that playing on the longer reach table does not only promote rallies but also requires more effort. The above comments by the players could be considered in carrying out further tests on the longer reach table tennis experiment in future.

5 Conclusions and recommendations

5.1 Conclusions

The longer reach table tennis may require slight modifications in existing rules. However, it does not necessitate any changes in the size and shape of the racket as currently used. The longer reach table tennis is not meant to replace the conventional table tennis, but it may be regarded as an additional table tennis event depending on the results of further tests. It is hoped that the longer reach table tennis will promote longer rallies, enhance athletic effort and visibility to both spectators and TV, and positively shape the image and status of modern

table tennis. Short players would not be disadvantaged on the longer reach table, because of the *still waters* area. Invariably, players have exactly the same playing area as in conventional table tennis; the only difference being that the table is extended in the middle.

5.2 Recommendations

Based on the results and analysis of the longer-reach experiment, the following are recommended to the ITTF for consideration:

5.2.1 In future tests, 40mm balls should be used. This might promote much longer rallies.

5.2.2 This experiment should be repeated in other countries in order to ascertain its validity.

5.2.3 The duration of the experiment should be increased in future tests.

5.2.4 Future tests should involve more female players.

5.2.5 The ITTF should organise invitational and exhibition tournaments using the longer reach table in order to test its public appeal.

5.2.6 Future experiments should involve defensive players.

5.2.7 The length of the gap in the still waters area could be adjusted to make it optimum for junior (under 14) and senior players.

5.2.8 In order to facilitate visibility and detection of faults by umpires when the ball lands in the still waters area, that portion could be covered with a green felt or electronic sensor (for Olympic and world-class competitions). Alternatively, the net may be fixed in the centre, supported by a pipe-like structure that facilitates the separation of the two halves of the table and provides a firm support for the net. A cloth or synthetic material similar to the net mesh might be used to cover the gap, which results from the separation of both halves of the table. In this manner, the length of the still waters area becomes adjustable.

5.2.9 The ITTF should consider the possibility of increasing the height of the net by 1.27 cm (0.5inch) or 1.91cm (0.75 inch). When the minimum angle of trajectory was measured from the net cord to the service line this amounted to an inclination of 22°. Whereas for the conventional table it yielded approximately 28° at 6cm beyond the net and 26° at 10cm away from the net. This means that if the current net height is retained, players' strokes would have easier clearance over the net. Other issues concerning possible modifications in existing rules are as follows:

- Is it a fault if a service lands on the service line? (See Figure 1).
- Should a game end at 11 points because rallies might be too long (especially if professional players are involved)?
- Should the longer reach table be extended at the centre by more than one metre to accommodate very tall players, e.g. American basketball players?

5.2.10 In conducting further tests, players' movements could be assessed with a three-plane accelerometer (E.g. Tritrac accelerometer). This would be helpful to quantify the amount and range of movement of players' limbs on the longer reach table. Also, when used in conjunction with the heart rate monitor it can more accurately estimate the intensity of play on the longer reach table.

5.2.11 Other international sport federations, e.g. soccer, volleyball and rugby have made a number of innovations, which have promoted the image and

popularity of the sports. A few examples are beach volleyball and five-a-side soccer. The longer reach table tennis presents an excellent opportunity for the ITTF to further promote the image and status of the sport world wide in the new millennium.

6 Acknowledgements

The authors are grateful to the following individuals and organizations who contributed towards the success of the experiment: The South African Table Tennis Board for granting the permission to conduct the experiment; the coaches, Messrs. Clement Meyer and Gregory Naik; the players who participated in the experiment; Mr. Ashley Albertyn who did the video recording and editing and Tessa Bavasah who magnanimously provided local transport and very warm hospitality. The kind hospitality received from Mr. Manuel Adams at Wetton, the entire Meyer family (i.e. Mr. Pedro Meyer, Mrs. Meyer, Mark, Jerome, Claire and Annamaria) and Mr. and Mrs. Bavasah is gratefully acknowledged. The authors are thankful to the Sanlam Table Tennis Club whose venue was used for the training programme and the staff of the South African Sports Science Institute who carried out the fitness testing. Colleagues in the Department of Kinesiology and Physical Education, University of the North, South Africa, who gave input and support to the experiment and indeed the University of the North, are gratefully acknowledged. Finally, profound appreciation is extended to the ITTF for sponsoring the experiment.

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