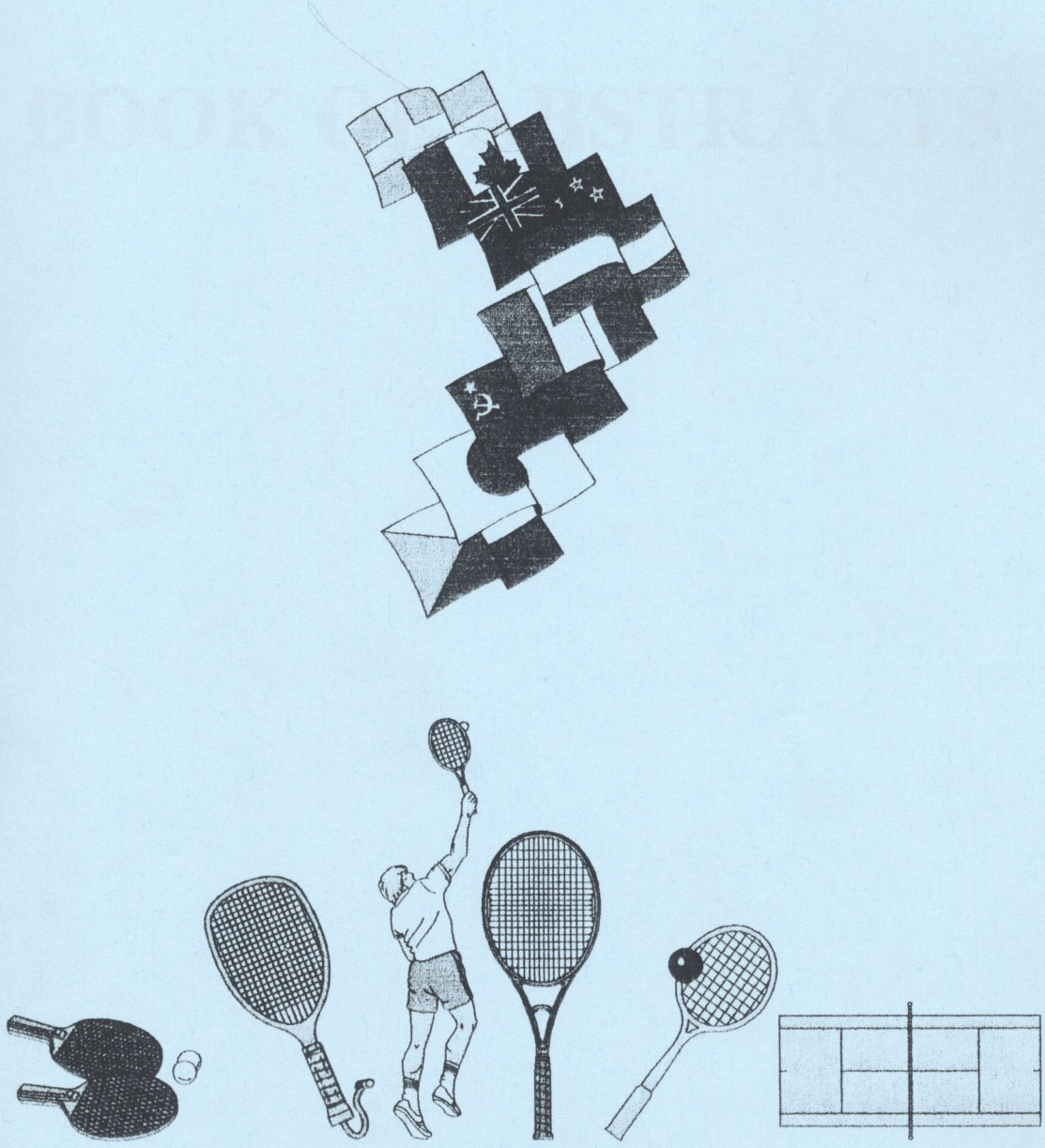
FIFTH
INTERNATIONAL
TABLE TENNIS
FEDERATION
SPORTS SCIENCE
CONGRESS

SECOND
WORLD CONGRESS
OF
SCIENCE
AND
RACKET SPORTS



BOOK OF ABSTRACTS

THE SECOND WORLD CONGRESS OF SCIENCE AND RACKET SPORTS.

and

THE FIFTH INTERNATIONAL TABLE TENNIS FEDERATION SPORT SCIENCE CONGRESS.

Lilleshall National Sports Centre, England, 22-25 April 1997.

ABSTRACTS

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ABSTRACTS

International Table Tennis Federation (I.T.T.F.).(Sponsor).

A Different Setting by Ian Marshall (I.T.T.F. Events Manager)

The venue of the National Sports Centre at Lilleshall in Shropshire for the Sports Science Congress is a far cry from the bustling port of Taianjin where the last congress was held two years ago. Lilleshall is in the heart of England's largest inland county and represents an idyllic setting for sportsmen and sportswomen to meet, to further their achievements and discuss the future of their chosen sport. A major aspect of the work at Lilleshall is the Sports Injury Clinic where the stars of modern day can receive top class assistance to aid their recovery back to full fitness, it is a centre which caters for all, from novice to World class performers.

The centre, especially Ford Hall, has been the home of many England Table Tennis Training Camps whilst tournaments have been held in the newly renovated Wenlock Hall. The studio in Queen Elizabeth Hall is used on a weekly basis for coaching. Table Tennis is a regular visitor to these excellent premises where a warm welcome and out-standing co-operation from all members of staff is assured.
Sports Science has become an increasingly important aspect of sport, in order to achieve maximum potential the modern day athlete must be well organised, plan carefully, eat properly and show self discipline. Only few have the mental and physical attributes to meet such demands and thus it is those precious few that become the stars of the sport. The financial rewards and the adulation afforded to world class sportsmen and sportswomen does not come without hours of effort and years of sacrifice.

The technology which has been applied to the athlete is also applied to the equipment. Manufacturers strive in a never ending quest to provide equipment that will give the player that vital point or split second over their opponent. However, it is important that technology is for the benefit of sport and it does not spoil the sport as a spectacle. The sport of Table Tennis must be well aware of the impact of technology on the game. Table Tennis has become a fast and highly physical sport, it is no longer the sport of the parlour as the name might suggest where landed gentry participate in light after dinner recreation. The game has advanced incredibly, new racket coverings gave spin and speed a new meaning; new training techniques have placed a great emphasis on the fitness of the players. However, we must be careful that the progress does not reduce the appeal of the sport to the spectator and especially to the layman who has simply come to watch sport and perhaps does not understand the intricacies and finer points of the game.

It is essential that both live and on television that the spectator can see what is happening, it is no great spectacle on television to see a player twist his body, produce what seems to be a harmless serve and the opponent seemingly makes a totally unforced error in returning the ball. It is important that the spectator can see the ball. can see what is happening and that whether the rallies be short or long they can be understood by the spectator.

The International Table Tennis Federation is aware of the need to undertake research to enable the sport to progress and make the sport grow in popularity. Sports Science has a valuable role to play and together a great sport can be made even greater.

The Coach And Sports Scientist Working in Harmony

Don Parker.
British Olympic Association.

The focus initially will be to look at the relationship that should exist between the player, the coach and the support team. Clearly the whole structure has to be player focused with everybody working in a co-ordinated manner to maximise performance. A key area for the player is the whole process of programme planning and producing peak performances at the major events. The process is one that requires input from the 'whole service team' and is crucial in producing champions.
Once an 'holistic' approach has been adopted it has to be nurtured by the respective sports to gain maximum effect. A good example of this was the SSSP project between the E.T.T.A and West Sussex Institute of Higher Education. Another area is of course how the relationship between coach and Sport Scientist is effected by competition. In preparing for Atlanta the B.O.A had a clear plan to how 'services' would be available both prior and during the games. During the games the British Table Tennis Team had a clear strategy and role for the Sport Scientist. Finally the whole area of confidentiality is one that needs to be considered.

Nutrition for racket sports

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Racket sports, in general, may be considered endurance sports, incorporating periods of intense exercise interspersed with lower levels of activity for 60 minutes and more. The estimated energy requirements for playing the various racket sports are between 25 and 71 kJ (7 -17 kcal) per minute. For a 70 kg player the result could be the loss of approximately 110-270 g of carbohydrate in one hour of play. Many matches will last for 2-2.5 hours, and so the carbohydrate loss is exacerbated. Since the body stores of carbohydrate are limited (approximately 300-400 g), the loss of more than 100-200 g of carbohydrate is significant. If the muscle stores of carbohydrate are not adequately replenished, then subsequent performance will be impaired.

The energy demands of racket sports are such that there is likely to be a significant production of heat within the body. Even in cold conditions, considerable amounts of sweat are lost in an attempt to dissipate this heat, thus resulting in a degree of dehydration. A mild degree of dehydration will impair skilled performance, and affect strength, stamina and speed. An adequate fluid intake is necessary to offset the effects of dehydration.

Despite the fact that the major causes of fatigue in multiple sprint sports are the depletion of muscle glycogen stores and dehydration, players are forever looking for nutritional supplements to help improve their performance and aid recovery. Vitamins and minerals are the legal products that players may consider, although substances such as creatine, sodium bicarbonate, and caffeine are also used.

This presentation will examine the nutritional requirements of the racket sports in terms of energy, carbohydrates and fluid intake. A brief examination of will also be undertaken of some ergogenic substances, before recommendations made for support before, during, and after training/competition.

Cardiorespiratory adjustments in middle-level tennis players: are long term cardiovascular adjustments possible?

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In the present research seven well trained middle-level (not professional) male tennis players were studied to assess the cardiac and respiratory responses to their actual sport performance. The subjects, who ranged in age between 25 and 35 years old, were tested both in the laboratory and during fifteen matches. In the laboratory the maximal oxygen uptake and the ventilatory threshold were assessed through a continuous incremental treadmill exercise test. Pulmonary ventilation, oxygen uptake, carbon dioxide production and heart rate were measured in field conditions through a telemetric device (K4, Cosmed) during a simulation of regular matches performed on a clay court. The duration of each rally (corresponding to the time in which the ball was in play), the duration of the break between rallies and the total time of the match were also measured. The laboratory and the field measurements were compared with the aim of establishing if the energy demand and the heart rate during regular matches were sufficiently high to stimulate long term cardiovascular adjustments, i.e. if playing tennis by itself constituted training for the heart. On the basis of the kind of play of the subjects that is the style and the tactics (players who prefer to play from the baseline, attacking players who play volleys often and players who play a mixed game) the duration of each rally ranged from 5.13 ± 0.9 seconds (corresponding to 21 ± 2 % of the total time) to 15.7 ± 4.5 seconds (corresponding to 38.5 ± 4.9%). The same pattern was found in the oxygen uptake and in the heart rate which varied widely depending on the characteristics of the game imposed by the style and the tactics of the players. The oxygen uptake and the heart rate were on average 30.9 ± 7.6 ml·kg^{-1}·min^{-1} and 123 ± 9 beats·min^{-1}, when the opponent was an attacking player and 37.5 ± 7.7 ml·kg^{-1}·min^{-1} and 159 ± 6 beats min^{-1} when both players played from the baseline. Only in the latter case the values of oxygen uptake and the heart rate were sometimes close to those measured at the ventilatory threshold (52.7 ± 2.9 ml·kg^{-1}·min^{-1}). These results show that tennis can be considered aerobic training with possible beneficial effects on the heart only when the duration of the rally is typical of a match in which the subjects play from the baseline.

IS THE INHIBITION OF SMASHING AND SERVING MOVEMENTS DUE TO ANATOMICAL VARIATIONS ?

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All muscles crossing the glenohumeral joint (art. Humeri) participate with high intensities and combined spurt- and shunt function in all overhand (above 90° abduction with rotation) movements. These muscles involve a series of thorax, back, shoulder and intrinsic arm muscles and are particularly trained to reinforce throwing, pitching, smashing, grip and serving. In combination with this reinforcement we experience a high level of stabilisation and precision. Often we see these different qualities disturbed in throwing and racket sport athletes.
A series of pain and compression syndromes collected within the terminology of "Thoracic Outlet Syndrome" and "Instability Syndromes" are most of the time pointed out as the cause and the motion disturbing mechanism.
The thoracic outlet syndrome and shoulder instability provoke well known and partly similar sensations, often described by the athlete as "my arm feels dead... I have no strength in my arm... I feel pins and needles in my arm...". In axillary surgery, there are sometimes reports of a fibromuscular band or string crossing the axilla. In the dissection room these bands are well known. Their reported incidence being about 10% at post mortem. Generally they are variations of the latissimus or the pectoralis major muscles, the most common form being known as the axillary arch or the arch of Langer. Simulations of abduction in combination with external rotation on dissected cadaveric material suggest neurovascular compression at the transition from the axilla to the upper end of the brachial neurovascular bundle. Dissection confirms that the band is innervated by branches from the ansa pectoralis with a blood supply from the lateral thoracic artery. Following a case study, where axillary arch negatively influenced the patient's occupational skills, an extensive echo graphic* in vivo study of 1321 subjects (1179 male, 142 female) was undertaken. A total of 188 arches was detected in 112 subjects (8.50%), mostly occurring bilaterally (incidence 5.80%). The incidence of the arch of Langer suggests that one should consider the possible presence of this anatomical variation... in the differential diagnose of thoracic outlet and shoulder instability syndromes.
These findings also suggest that 10% of racket sports athletes could see their serve, smash... and grip quality decrease because of the "unknown" presence of an axillary arch.

** the visualisation of ultrasound echo*

An Experimental investigation into the Influence of the Speed and Spin by Balls of Different Diameters and Weights

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(Abstract)

With the development of table tennis and the improvement of player's techniques ,the ball's speed and spin in matches have become too fast for ordinary spectators to appreciate ; Moreover the rallies of each point have decreased apparently to make spectators lose their interest in table tennis matches.

In order to regain spectators interest, recently ITTF suggest that if the ball's diameter increases 2mm from currently 38mm to 40mm,the ball's speed and spin might be reduced and the rallies will be more to make table tennis matches more interesting for spectators. For the attainment of feasible scientific statistics,ITTF entrusted the Sport Science Committee of the Chinese Table Tennis Association to carry out a experiment on the influence produced by balls of different diameters and weights.

The PD-1 Dynamic Spin-speed Meter and Motion Analysis System Peak 5 was used in the test. Each of the three chinese players played F.loop, attack and smash 10 times for speed testing and 50 times for spin testing for each types of strokes with 3 differrent balls: ball A=weight 2.51g, diameter 38mm; ball B=weight 2.79g, diameter 40mm; ball C=weight 2.49, diameter 40mm. The average speed and spin were calculated. The results are as follows:

1. The speed of B(17m/s) and C(15.4m/s) for smash are slower than that of A(17.8m/s). C and A are significantly different ($P<0.05$). B and A do not show significant difference ($P>0.05$). Similar results of attack are found .
2. The spin of B(116.5 r/s) and C(105.8 r/s) for loops are less than that of A(133.5 r/s), with a significant difference ($P<0.05$).
3. The heavier 40mm balls(2.65-2.80g) with bounce 24.5mm hit more rapidly than the lighter 40mm balls with bounce 23.8mm.
4. Different effect on balls of three kinds are found when the striking strength is different. Smash has a higher deduction rate than attack.
5. The weight and bounce have different effect on the speed and spin. Stronger influence is found on speed than on spin.
6. The test shows that the speed and spin of the larger balls are slower and less than that of the small ones. If the larger balls are adopted in the game, it will be favorable to make the matches more rallies and attract more spectators.

Conditioning For Tennis : Preventing Injury And Enhancing Performance.

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To prepare tennis players for maximum performance, both the physiological demands of the sport and the musculoskeletal base of the individual athlete should be evaluated. Fitness testing can provide a baseline fitness level for the individual athlete, and provide normative data.

Competitive tennis has evolved into a game requiring high levels of physical and athletic fitness. Conditioning for tennis should involve building a general athletic fitness base (strength, muscular endurance, cardiorespiratory endurance), then progressing to sport specific athletic fitness (speed, power, agility, balance). Many resistance training regimens have been shown to be effective in improving performance related parameters. Due to the inherent risk of plyometric exercises, they should be carefully monitored by qualified personnel.

Tennis players provide many challenges to planning conditioning programs, including constant travel and a long in-season. By designing a conditioning for tennis based on defining specific "periods", and by using each "period" to train specific aspects of tennis performance in a progressive manner, performance will hopefully be maximised.

Principles of sound exercise program design; specificity, individuality, recovery, progression and variety are important both to maximise performance and modify injury risk. Repetitive strain injuries are common in the tennis athlete. The goal of "preventing" injuries is commonly discussed, but will not likely be reached in high-intensity ballistic sports.

The metabolic and mechanical demands of tennis have been reported in recent literature. Tennis requires repeated bouts of moderate to high-intensity exercise. Evaluation of the individual athlete in terms of muscle strength and weaknesses of the individual tennis player. Ongoing tennis research in such areas as metabolism, fluid replacement, work-rest intervals, muscle firing patterns, musculoskeletal adaptations, will continue to provide useful information that can be incorporated into the tennis conditioning program.

Metabolic responses and performance in tennis after caffeine ingestion

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The purpose of the study was to investigate the effects of caffeine concentrations, common in commercial available beverages, on metabolism and performance during a 4 h interrupted tennis match (30 min rest after 150 min). Sixteen tournament tennis players (division II in German Tennis Federation), 8 male (25.4±1.9 yrs, 184±5 cm, 81.1±7.3 kg) and 8 female (20.4±2.8 yrs, 170±4 cm, 65.0±4.6 kg) participated in the study. At every court changeover and during the 30 min rest players ingested, on two randomized and double-blind occasions, an orange flavoured placebo (PLA) or PLA supplemented with 130 mg/l caffeine (CAF). Total daily ingestion in men (women) was 2.8 l (2.0 l) fluid, supplemented with 364 mg (260 mg) caffeine. Post-exercise, all players performed a ball-machine test (BMT) to assess hitting accuracy and a tennis-sprint test to evaluate tennis-specific running-speed. Perceived "energetic drive" was monitored by a newly developed scale (ten point scale ranging from very low (1) to very high (10) willingness to perform).

During match play blood glucose declined only slightly and did not differ between CAF (5.1±0.9 mmol/l) and PLA (5.0±0.5 mmol/l) after the competition. Immediately after the resting period blood glucose temporary declined in PLA (from 5.1±0.7 to 3.9±0.5 mmol/l), while no significant changes occured in CAF. Increases of serum FFA (1.44±0.39 vs 1.29±0.41 mmol/l) and glycerol (0.28 ±0.09 vs 0.25±0.13 mmol/l) as well as the decrease of insulin were similar during the CAF and PLA trials. Mean heart rate (140±14 vs 141±14 bpm) and blood lactate levels (1.6±0.7 vs 1.6±0.5 mmol/l) did not differ between the CAF and PLA treatments as well. Post-exercise urine concentrations of adrenaline (2,0±1,0 vs 1,6±0,7 µg/mg creatinine) and caffeine (6,6±1,1 vs 1,1±0,9 µg/ml) were significantly higher in CAF. In all subjects urine caffeine concentrations remained below the doping limit (maximum value was 9.3 µg/ml). Sprint performance, hitting accuracy (BMT), perception ratings and playing success were not affected by treatment for the whole group of subjects. Nevertheless, women perceived a higher energetic drive (willingness to perform) during the last hour of competition (6,8±1,4 vs 5,1±1,7) and played more successfully under caffeine feeding. The number of games won in the CAF trials (28.1±5.5) exceeded those during the PLA trials significantly (21.1±5.6).

In conclusion, CAF did not result in a stronger stimulation of lipolysis and no effect on blood glucose during continuous match play was shown. Nevertheless, data indicate that CAF accelerates the regulation of blood glucose at the beginning of work load and and has specific ergogenic effects on performance and perception in women´s tennis.

Body fluid loss during competitive tennis match-play

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A longitudinal study of the training of young athletes (Rowley, 1992) revealed that junior tennis players aged between 12 and 14 years were on court for 7 and 10 hours per week, respectively. Throughout training and competition, players must be able to maintain technique and concentration along with the ability to react and move rapidly around the court. Progressive dehydration by as little as 2.7% body mass, can cause a 20% increase in errors (Burke and Ekblom 1982). The aim of the present study was to assess the body mass losses incurred by junior tennis players when participating in a Junior County tournament. Matches were the best of three sets, with a tie break played in the first two sets. Fourteen male and six female junior County tournament standard tennis players, aged between 12 and 14 years, volunteered to be subjects whilst participating in the tournament. Play was outdoors on a hard court surface (En-Tout-Cas™). Subjects' dry body mass was recorded before and after each match (kg). The body mass loss was adjusted for the volume of fluid ingested. Players were permitted to drink beverages of their choice ad libitum throughout each match. Fluid intake (ml), match length (min), dry bulb temperature (°C) and relative humidity (%) were recorded for each match. A one-tailed t-test for correlated data was performed to determine the changes pre-match to post-match. A Pearson product moment correlation was performed between fluid intake (ml) and body mass loss (kg). Body mass declined by 1.3 ± 0.1 kg from a pre-match value of 54.7 ± 3.9 kg (mean $\pm$ S.E.M) to a post-match value of 53.4 ± 3.8 kg ($P<0.01$). This corresponded to a body mass loss of $2.3 \pm 0.2\%$. Mean fluid intake was 1089 ± 95 ml and ranged from 328 ml to 1750 ml. Match length ranged from 50 min to 140 min with a mean value of 86.3 ± 6.5 min. Dry bulb temperature (°C) and relative humidity (%) were 27.8 ± 0.5 °C and $43.2 \pm 3.1\%$ respectively. The net losses in body mass reflected fluid loss, despite the ad libitum ingestion of fluids. A negative correlation [$r= -0.54$] ($P<0.05$) was observed between body mass loss and fluid intake. These results would seem to support the common view that thirst is a poor indicator of dehydration. However, such responses may vary between individuals, depending upon their education and training. It must be emphasised to all tennis players, that the most effective defence against dehydration and hyperthermia is through the regular ingestion of fluids. This is especially important in children and when playing competitive tennis in a hot environment.

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Fluid Replacement in Table Tennis Players.

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Abstract

During prolonged exercise the loss of body water and electrolytes in sweat leads to a more or less strong decrease of work intensity. In this study the aim was to examine, whether fluid substitution with various beverages had different effects on the playing ability of table-tennis players during prolonged exercise.

Eighteen table-tennis-players played three times against a table-tennis robot (TT-MATIC 500 ®) that had been standardized. Two experimental groups were formed (group one = G1, group 2 = G2). To which group the players belonged, depended on the league (according to the DTTB-leagues of 1992) they played in. So nine players which played in the DTTB-leagues 1 to 4 were in group one whereas the other nine players which played in the leagues 7 to 10 formed group two. So in group one played the better table-tennis-players, in group two the less good players.

The robot played 60 balls per minute with a slight forward rotation. It was controlled by a random processor. During every trial the subjects played 9 times for 10 minutes with 3 minutes break between the playing time. Therefore, the net playing time of one trial was 90 minutes. The difference between the three trials was the substitution of the beverages. In one trial the subjects drank Isostar® (ISO). During another trial apple juice which was diluted with the to fold volume of tap water (APPLE). The drinking amount for ISO and APPLE was 13ml/kg weight , equally distributed over all the breaks. During a third trial no drinks were allowed (NO FLUID). The trials were separated by 5 to 33 days.

The task of the subjects in each trial was to hit a surface fixed on a table -tennis table as often as possible. The surface was 1/6 the size of a table-tennis-table half. Just before and after the trial the subjects were weighed. During the trials the heart-rate was measureded by means of short range radio telemetry (POLAR ELECTRO ®).

During the NO FLUID trials the subjects showed the highest loss in body weight (median G1 = -1.4 kg [range -0.8 to -2.0], median G2 = -1.0 kg [-0.9 to -2.3]) followed by the APPLE (median G1 = -0.7 kg [+/- 0 to -1.1], median G2 = -0.4 kg [-0.2 to -0.9]) and ISO (median G1 = -0.5 kg [-0.1 to -1.2], median G2 = -0,3 kg, [+ 0.2 to -0.9]) trials. The heart-rates were highest during APPLE (median G1 = 156 bpm [132 bpm to 171 bpm]; median G2 = 134 bpm [94 bpm to 183 bpm]), followed by NO FLUID (median G1 = 144 bpm [103 bpm to 179 bpm], median G2 = 132 bpm [98 bpm to 170 bpm]) and ISO (median G1 = 143 bpm [131 bpm to 172 bpm], median G2 = 133 bpm[100 bpm to 178 bpm]). The highest hitting-rate was during APPLE (median G1 = 81.5 % [72.6% to 90.6%], median G2 = 72.6 % [56.2 % to 79.9 %]) followed by NO FLUID (median G1 = 78.9 % [69.6 % to 84.9 %], median G2 = 68.7 % [62.7 % to 76.2 %]) and ISO (median G1 = 78.3 % [67.2 % to 87.9 %], median G2 = 67.2 % [56.2% to 75.9%]). For the hitting-rate the differences between APPLE and ISO were significant ($\alpha = 0.02$).

The isotonic solution contained Na (23.58 mmol/l), Cl (9.01 mmol/l), K (3.06 mmol/l), Mg (1.81 mmol/l) and Ca (1.99 mmol/l). The diluted apple juice contained 0.43 mmol/l of Na, 0.46 mmol/l of Cl, 10.23 mmol/l of K, 0.71 mmol/l of Mg and 0.49 mmol/l of Ca. The most striking difference between ISO and APPLE was that in the hitting-rates the players showed better performance with APPLE than with ISO. As the heart-rates were highest during APPLE, it might have been possible that the players needed higher heart-rates in order to reach better hitting-rates. Referring to the weight-loss we suppose that ISO might have handicaped the sweat-rate. Sweating is important for the cooling of the body and the regulation of body temperature. We didn`t measure the body-temperature during the trials. Except for the hitting-rates we couldn`t find significant results for these hypotheses.

The main result of this study is: substitution of fluid loss with the mineral drink Isostar® is inferior to substitution with diluted apple juice with respect to the hitting rate during a 90 min table-tennis test.

An exploration of the training of university student Table Tennis players at altitude.

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The aim of investigation was to assess the influence of training at altitude when playing Table Tennis matches at sea level. The effect of altitude training on physiological function is well documented with a number of adaptations occurring. In the first condition of this experiment the university teams trained at sea level before competition and finished 7th in the men's team competition, 8th in the men's doubles, 7th in the women's team competition and 8th I the women's singles. However, after a period of training at altitude the same teams finished 4th in the men's team competition, 4th in the men's singles, 7th in the men's doubles, whilst the females finished 8th in the women's singles. The results suggested that training at altitude, but playing matches at sea level produces better results. The authors feel this advantage may be even greater for the defensive style of players who rely to a greater extent on fitness. It is further suggested that athletes from more sports should consider the benefits of training at altitude.

THE APPLICATION OF REFLEXRESPONSE THEORY TO ALL RACKET (AND OTHER REFLEX INTENSIVE) SPORTS.

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Measurement principles as necessary to establish an international reflexresponse measuring unit (EHRT) are presented. The Miller/de Wilde curves indicating the preliminary relationship between human reflexresponse time, age and population percentile are analyzed and explained. Reflexresponse principles are used to demonstrate the sequential reflexresponse dynamics that take place when two approximately equally experienced competitors each having a different EHRT capability compete against each other in any racket sport. It is concluded that reflexresponse times vary significantly between individuals and that these variations can have a major influence on a competitors win/lose record.

ENHANCING THE EFFECTIVENESS OF CURRENT NATIONAL JUNIOR RECRUITMENT AND SELECTION PROGRAMS USING REFLEXRESPONSE TECHNIQUES.

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The current (Random Chance) junior recruitment programs presently utilized for all racket sports are analyzed in the light of available reflexresponse knowledge. They are found to be wanting. A forecast of a pending change in national overall recruitment systems is made. A new, more efficient upcoming racket sport recruitment system (Selective Invitation) is outlined and a method for its implementation into all of todays racket sport recruitment programs is proposed. Some tough questions for those racket sports organizations who resist the change and remain with the old (Random Chance) selection systems are fielded and predictions of the possible consequences are made. It is concluded that integration of reflexresponse techniques into all racket sport national junior recruitment programs could radically improve the discovery sequence of high potential juniors and simultaneously reduce the age at which these juniors take up their chosen racket sport activities.

New Technique For Measuring Ball Rebounce Coefficient For Table Tennis Surface

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Abstract

Studying the dynamics of the rebounce in table tennis requires some sort of recording device. Different types of table tennis may produce different ball rebounce. This would affect the speed of the ball as it leaves the tables, which affects the accuracy of various strokes in table tennis.

A previously developed technique by the authors have been used to measure the rebounce coefficient for soccer field surface. This technique is described in this study to show its applicability for measuring the rebounce coefficient of table tennis.

The rebounce coefficient measurement system is composed of ball release mechanism, bounce detector, a timer and table tennis. When the ball touches the surface of the table, the first bounce is picked up by detector and activates the start of the timer. After short period of time, the second bounce is picked up by the detector and the timer stops timing. An average value of t is then calculated and recorded.

The rebounce coefficient can be measured using the following developed equation.

$$e = (0.781)\, t$$

The system is designed to be user friendly, inexpensive and designed to provide information on the quality of tables as well as balls under any condition. The system does not interfere with ball free nor with the table.

The Importance Of The Speed Of Ball Flight For The Performance Of Junior Tennis Players.

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The purpose of this study was to investigate the relationship between the ball speed of certain strokes of junior tennis players and their ranking, based on their performance in the official games of the Hellenic Tennis Federation, in the 'boys under 12'age category. The junior players studied were eight boys, aged 11 and 12, who ranked in the top 8 in their category in Greece. The measurements were carried out during the 2nd official junior Championship in the 1996 Games, which were played on clay courts. The speed of the ball flight was measured on the following strokes : 1st service (SE1), 2nd service (SE2), forehand (FO) and backhand (BA). Specifically, 20 strokes were measured for each player. For the speed calculation, the RADAR GUN PSK II PROSPEED of Decatur Electronic was used. It has been found to oscillate at 4951 ± 5 Hz at 70 F. It will cause a Doppler traffic radar transmitting at 24/50 Ghz to display 110,6 Km/h. The radar gun was placed 7m behind the opposite baseline and in a position that the distance between the player and the radar gun fluctuated between 20-30m. The ball's speed was measured when the player, who hit the ball, was at an angle of less than 10° in relation to the radar gun. The data was analysed with the statistical package SPAD-N Ver.2. The results indicated that the contribution of the 'ball speed flight' factor was non significant, as far as the ultimate performance of the player was concerned.

A Research of Improving the Sensitivity of the Grip Joints by Adopting the method of Multi-ball practice in Table Tennis

By Cai Jiling, Li Wei

Abstract Under the principle of training--more difficult, more strict and more amount of exercises, the method of multi-ball practice was invented in the early 60's of China. It was first put in practice of table tennis in China and later extended to all over the world. It has been regarded as an effective training method. It can increase the training density and the unit of time as well as the stamina, It also plays an important part in cultivating the strong will of the player.

The improvement of the sensitivity of the grip joints has close relationship with the increasing accuracy of batting. This article will approach the subject.

There was an experiment that we divided the players into very small groups and examed both the physiological and technological targets before and after the experiment. We want to know whether the sensitivity of the grip joints have been increased or not.

From this experiment, we proved that the method of multi-ball practice in improving the sensitivity of the grip joints.

44 REGIONAL BODY COMPOSITION IN PROFESSIONAL TENNIS PLAYERS

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The wholebody and regional body composition of nine male tennis players of Gran Canaria island and 17 non-active subjects from the same population was assessed using dual X-ray absorptiometry (Hologic-QDR-1500). The mean (±SD) age, body mass and height was 26 ± 6 and 24 ± 3 years, 77 ± 10 and 74 ± 9 kg and 180 ± 6 and 178 ± 6 cm, for the tennis players and the sedentary subjects, respectively. All the tennis players had been participating in profesional or first level amateur tennis competitions during, at least, the last seven years (17 ± 6). The mean time they have been spending in tennis training or competitions have been 25 ± 8 hours per week. The whole body composition for bone mineral content (BMC), lean body mass and body fat of the tennis players was 3078 ± 476 g, 60188 ± 5727 and 12981 ± 6553 g, respectively, whilst the percentage of body fat (%fat) was 16.5 ± 6.7%. Marked differences were seen between the dominant and the contralateral arm in the tennis players for BMC (188.2 ± 31.9 vs. 229.0 ± 43.5 g, $p<0.001$), lean mass (3148 ± 380 vs. 3772 ± 500, $p<0.001$) whole mass (4220 ± 632 vs. 4977 ± 908, $p<0.001$) and %fat (20.3 ± 8.8 vs. 18.7 ± 8.6%, $p<0.05$). On the other hand, the control group also showed a slightly higher muscle mass in the dominant arm (3246 ± 421 vs. 3093 ± 388 g, $p<0.01$). Conversely, fat mass was lower in the dominant arm (749 ± 274 vs. 793 ± 278, $p<0.05$), as it was the percentage of fat (17.7 ± 5.3 vs. 19.2 ± 5.7, $p<0.01$). In addition, the sedentary subjects showed similar BMC in both arms (194 ± 33 vs. 193 ± 32 g). When comparing the arms between groups, total and lean mass, as well as BMC were higher in the dominant arm of the tennis players ($p<0.05$). Minor asymmetries were also observed at the leg level in the tennis players, as well as in the control group. In the tennis players the right leg was slightly heaviest than the left leg (13236 ± 1779 vs. 13033 ± 1826 g, $p<0.01$), due to the highest fat content of the right leg (2518 ± 1177 vs. 2331 ± 1070 g, $p<0.05$). Nevertheless, only the fat content was slightly increased in the right leg of the control group (2998 ± 1120 vs. 2856 ± 1045, $p<0.05$), while the total mass and the lean mass, as well as the BMC were similar in both sides. In summary, this study shows that the marked arm asymmetry usually seen in tennis players is due to the existence of about 20% more bone mineral content and muscle mass in the dominant than in the contralateral arm.

Fluid loss during international standard matchplay in squash.

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It is well established that dehydration can reduce the performance capabilities of sportspeople. Squash is a sport which presents a considerable challenge to the body's thermoregulatory system and previous studies have demonstrated fluid losses of 1.8 $l.h^{-1}$ in top club players (Rensburg et al., 1982, S.A. Journal for Research in Sport, Physical Education and Recreation, **5(2)** : 25-56). As the demands of international competition are not well documented, the purpose of this study was to investigate fluid losses during international standard matchplay in squash.

Fluid losses were assessed in 8 matches at the World Cup team event in Malaysia which was held in May/June 1996. Three male members of the England squad were used as subjects. Court temperature and humidity were measured using a combined digital thermometer and hygrometer (A.T.P. Instrumentation Ltd Model HT-23, Ashby-de-la-Zouch, Leics, UK). Fluid loss was estimated from measurements of body mass before and after matches. Body mass was measured to the nearest 100g using electronic scales (EKS Model 6010, North Finchley, London UK). The scales were calibrated prior to and on return from the competition using beam balance scales (Herbert and Sons). The volume of fluid ingested during the matches was measured using food scales (EKS Model 1002, North Finchley, London UK). These data were used to calculate net body mass loss which was then converted to a rate of fluid loss ($l.h^{-1}$). It was assumed that virtually all the reductions in mass represented fluid lost as sweat, where 1 kg of mass loss corresponded to 1 litre of sweat. Body mass was recorded prior to the warm up, and within 10 minutes of the match ending after the players had been towelled dry. Rates of fluid loss were based on the total time between the pre and post-match measurements being made.

Court temperature and humidity (n=8) for the matches were 25.1 ± 1.3 °C and 64 ± 6 % (mean ± SD). Overall fluid loss (n=8) was 2.37 ± 0.45 $l.h^{-1}$ (subject A, n=3, range 2.08 - 2.82 $l.h^{-1}$), (subject B, n=3, 2.10 - 2.93 $l.h^{-1}$), (subject C, n=2, 1.68 - 2.70 $l.h^{-1}$). The rates of fluid loss in this study are higher than those reported previously (Rensburg et al., 1982). Although some of the reductions in body mass are attributable to substrate utilisation, the majority are the result of fluid lost as sweat. The results demonstrate the demanding nature of international standard squash and provide guidelines which can be used to inform hydration strategies at this level of play.

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An Aerobic Test Specific For Table Tennis Players

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There is a lack of physiological data on the performance capacity of table tennis players, whose fitness requirements are highly specific. The purpose of this study was to compare the physiological responses of table tennis players to a sport specific field based aerobic fitness test and a general field based aerobic fitness test (multistage shuttle run test). Fourteen elite (National Junior Squad) table tennis players (mean ± S.D.), (age 14.9 ± 1.6 years) completed the two fitness tests in a randomised, counter balanced order. The sport specific test was conducted on a table tennis table in a recognised match play environment. A table tennis "ball firer" projected balls to players for a six second period. Players were required to return the balls as fast and accurately as possible using alternate backhand and forehand strokes. The subject then performed a combination of table tennis related side stepping movements to five constant markers placed on the floor, within a set period of time. Exercise intensity was controlled by a progressive reduction of time (one second) at each level of the test. When the time period was completed a further ball was projected from the ball firer. If the subject was not in the correct position to return the ball, then the test was terminated. Thus, an index of table tennis aerobic fitness was determined with reference to exercise time to fatigue. These sport specific fitness indices were then compared to results from the multi stage shuttle run test ($r = 0.30$, $p = 0.29$), as an initial measure of concurrent validity. Other variables collected from both tests were post-test heart rates beats.min $^{-1}$ (table= 199.7 ± 8.0, multi stage =199.5 ± 8.4 b.min^{-1}) perceived exertion (table = 16.9 ± 2.1, multi stage = 16.7 ± 2.1) and elimination level. The results showed no difference for post-test heart rates or perceived exertion. This suggests that both the sport specific test and the multi stage fitness test achieved similar levels of maximum heart rate and perceived exertion. The low correlation between the two tests suggests that the tests were not measuring the same fitness parameters, which further indicates the need for a sport specific aerobic test. Future research will establish more sensitivity within the different stages of the test by introducing more constant levels at each progressive stage. Early trends indicate that a field based sport specific fitness test may more accurately assess fitness in table tennis.

Studies of Forehand Strokes in Table Tennis by 3 Dimensional Analysis using the DLT Method

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Abstract

In order to investigate ways to improve the basic techniques of non-skilled players the motions of forehand strokes in Table Tennis were analyzed by 3 dimensional analysis, using the DLT method. Six male subjects participated in this study. Three subjects were trained and three were untrained. Subjects hit the balls towards a target point on the opposite side of the court. The hitting motions of the players were recorded by 2 synchronized video cameras. Stick pictures from views of the X axis, Y axis, Z axis and other axes were derived by a 3 dimensional method. The results obtained suggest that trained players tend to move their wrist more efficiently, with punching knee, elbow and shoulder motions, with twist movements being more quick and keen during the forehand smash stroke, than that of non-skilled players. It was concluded that one way to improve the basic techniques of beginners was to move each part of the body required in the forehand stroke more gracefully.

Abstract

From the Laboratory to the Courts:

Understanding and Training Anticipation and Decision-Making

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Great advancements have been made in recent years as to conditioning racket sport athletes, establishing guidelines for nutritional requirements, and facilitating the mastery of technical skills and tactics. However, in spite of the realization of the importance of possessing exceptional anticipatory strategies and decision-making skills in situations with tight time constraints and uncertainty of opponent's intentions, little practical information has been generated from science as to how to improve the ways one might function most effectively in these situations. A first step is to understand how experts think and what they do, compared to the lesser-skilled. Indeed, a body of research profiles the visual patterns as well as decision speed and accuracy of experts and novices in simulated racket sport laboratory contexts.

One obvious finding is that the highly proficient athlete tends to pick up the most significant information at crucial times, and is able to maximize the meaning of minimal task-relevant cues, a process that might be termed pattern recognition. This leads to more accurate and faster anticipation of an opponent's intentions. Obviously, there is then more time to plan a response, to be at the right place at the right time, and to execute the action as intended. The expert-novice research is strongly suggestive of the importance to the racket player of developing appropriate strategies to channel attention, direct focus toward valid anticipatory cues, and to "read" situational probabilities and specific opponent tendencies and intentions quickly in any competitive situation. A particular response repertoire needs to be adequately developed and associated with intentions and actions of the opponent. How to do all of this?

Based upon our research and implications from research that indirectly bears upon the issue, practical suggestions can be made for the racket player with serious intentions about improving playing skill level. Off the court, a regular program of visualizing on court behaviors under different conditions should be implemented. Likewise, knowledge about the next opponent gained through direct observation or video tape can prepare one for the strengths and weaknesses of that opponent. Practice, on occasion, should simulate real competition. A simulated competitive stress environment should require the player to process information and react well consistently under varying circumstances.

Finally, when "real" competition day comes, the player should attempt to pick up as much information as possible about the opponent's strengths, weaknesses, and tendencies during the warm-up practice as well as the early points. With the objective of playing each match intelligently, and with more experience, less effort and deliberate consciousness will be expended toward cue awareness, anticipating, and reacting.

KNOWLEDGE BASED SYSTEM FOR THE SIMULATION OF DECISION MAKING OF THE SERVE-RETURN PHASE IN TENNIS: "LIFT" SYSTEM.

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The current evolution of competitive tennis shows the importance of the service. Considering the velocity of serves, the receiver must prepare his return without waiting for information about the trajectory of the ball. Keller (1985), Goulet et al (1988, 1989a, 1989b, 1992) suggest that receivers seem to use information from the server's body. Bartoszynski and Puri (1981), and Norman (1985) indicate that a statistical theory can also explain the choice of the type of serve. Lastly, the quality of the serve also seems to vary according to the court surface (Hughes and Clarke, 1994). However, the presented works analyze the receiver's decision making on the basis of only one source of information. Our objective is to propose a more complete decision making model. With reference to works about the specific domain of decision making in sporting contests (Gouard, 1993; Sarrazin et al, 1983, 1986; Singer et al, 1994), our problematic is based on the processing of expert knowledge for problem solving in sports. It takes place within the framework of Artificial Intelligence. The purpose of this study is to describe the conception and the development of a knowledge based system named LIFT (LIFT stands for Logique Informatique pour la Formalisation des connaissances en Tennis) which allows the simulation of the receiver's decision making during a tennis match. From the methodological point of view, two stages characterize our work. Knowledge acquisition from an expert tennis coach of the French Tennis Federation represents the first stage. In the second stage, the formalization of this knowledge allows us to elaborate a system reproducing the receiver's decision-making process. Finally, an implementation on a micro-computer was done in order to show the system working in real time and to facilitate its assessment.The first stage shows the use of three categories of information: Information available to the receiver before the match, visual information about the server just before he hits the ball and then, information about the evolution of the match. The second stage concerns the elaboration of the LIFT system. This system produces a prediction of the server's strategy (playing an ace or serving on the receiver's weak stroke), of the area aimed at by the server (down the line, cross-court, centre court) and of the spin used (kick serve, slice serve or flat serve), for each rally. A probability coefficent given as a percentage is attributed to these predictions. The LIFT system results in the use of two complementary models for the simulation of the receiver's decision making. The first model is a theoretical model based on information available to players before the match. The second model is an optimal model. Its originality concerns its ability to "learn" the real server's behaviour during the match in order to adjust the decision-making process. In particular, this second model takes into account not only tactical data (e.g. the way in which the points are won or lost by the receiver) but also technical data (e.g. the relationship between the direction of the toss and the type of serve). Thus this optimal model replaces the first as soon as a few points are played. The dynamic character of this type of working shows that it is possible to simulate the evolution of the receiver'decision making. However, the proposed system is not able to consider more subjective information such as tiredness or the pressure brought about by the importance of the match. It must equally be noted that the LIFT system does not try to explain the real receiver's decision making process, but only provides a model for simulating complexity of decision making . Finally, our system can also be used by tennis coaches who wish to give tactical feedback information to their players after the matches.

THE METHOD OF RESEARCH ON SPECIFIC MOVEMENTS SPEED AND ANTICIPATION IN SPORT IN SIMULATED CONDITIONS ON THE BASIS OF TABLE TENNIS

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In the paper the method of research on specific movements speed and anticipation in sport on basis of table tennis is presented. The tested subjects were 10 Polish national table tennis team players and 22 children. The Simulatory Timer of Movements Speed and Anticipation was used in the experiment. The timer consists of specific simulator, control card and computer. The specific simulator is applied for investigation of specific movements speed in a choosen discipline of sport and constitutes an exchangable element of the timer. The control card provides controling of the simulator. Programming enables to create measuring tests by oneself. In presented researches the simulator of play in table tennis was used. It consists of: stimuli board, set of sensors and special table tennis bat. There are 7 lamps of the size of table tennis ball on the board and also 7 sensors with the same lamps are adjusted to the tennis table. The simulator enables to test the speed of 7 different movements. The range of movements was 0.4 - 2.25 m. The investigated movements were divided on anticipated and simple sequential movements. The anticipated sequential movements were stimulated by 7 constant couples of lamps (lamp on the board and lamp in the sensor). Each of the lamp on the board in computer programme was connected with one of the lamps in the sensors . Both lamps were switched on sequentialy (simulation of ball flight). In that way the anticipation was taken into consideration in the researches. The simple sequential movements were stimulated only by lamps in the sensors. The subject`s task was to perform the simulated ball hitting in the places indicated indirectly by the lamps on the board (anticipated sequential movements) or directly by the lamps in the sensors (simple sequential movements). The simulated strokes of ball from forhand and backhand were executed by hitting with the special table tennis bat in flexible straps adjusted to the sensors. The time passed from switching on the lamp in the sensor to the moment of performing the simulated ball hitting was the measure of the speed of particular movements. The sensors identified the moment of simulated stroke of ball in a photoelectrical way enabling the performance of movements at maximal speed. The speed of 7 different anticipated and simple sequential movements was investigated in series (tests) of 17 measurements. The followings average speed (in seconds) of both tested kinds of sequential movements were found for: men 0.4 and 0.55, children 0.5 and 0.62. The anticipation and behavioral fluctuation indexes were introduced. The anticipation of coincidence was divided on anticipation of coincidence of place and of movement. Tke first kind of anticipation was investigated. The index of anticipation shows (in precentage) the level of increace of sequential movements speed as a rusult of anticipation of ball flight place. The followings indexes were obtained by: men 27.5, children 11.1. It means, that the children have much less capacity of anticipation. It was found, that the speed of anticipated and simple sequential movements and indexes of anticipation and of behavioral fluctuation highly correlate (0.89, 0.84, 0.80, 0.81) with sport ranking for members of the national team. These factors were used for the selection based on the clouster analysis. The clouster analysis enables to find very talented players and indicates the weak psychomotoric sides of less talented players. The simulatory timer may serve as a diagnostic device to investigate psychomotoric predestinations in various disciplines of sport. It can also be used as a training device to improve the speed of specific movements and such important factors as anticipation and concentration of attention.

Visual Search Strategy in 'Live' On-court Situations in Tennis: An Exploratory Study

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This study represents an initial attempt to assess visual search behaviour during 'live' on-court situations in tennis. Typically, previous research has been conducted under laboratory conditions with participants required to make simple responses to static slide or film presentations. The study also examined the extent to which performance among expert tennis players could be differentiated on the basis of their visual search patterns as they prepared for and executed the return of serve. Previous research has tended to compare experts with novices, rather than attempting a within-group comparison of high-level performers. Three male and two female highly-ranked players from the University of Florida tennis team participated in the study. Each player's visual fixations on the server and the ball, as well as their physical responses were recorded for ten successful service return situations. Visual search behaviours were recorded using an ASL 4000SU eye movement system. This is a video-based system which measures eye line-of-gaze with respect to a head-mounted scene camera. Participants' physical responses were videotaped from behind at a 45° angle. This video image was temporally synchronised with the head-mounted scene camera image, enabling a precise comparison of the players' physical actions with their visual search behaviours. Players fixated on the arm, shoulder and racket regions prior to the initiation of the serve. Thereafter, with the exception of one player who fixated on the server's racket, participants followed the ball to the apex of the toss by employing either pursuit tracking or saccadic eye movements. The greatest variation in visual behaviour was observed during ball flight, where players either maintained fixation on the ball via pursuit tracking or employed a predictive saccade approach to fixate the expected ball bounce area. Those who employed pursuit tracking during the initial ball flight period maintained fixation on the ball after it bounced until on average 150-200 msec (2-4 metres) before ball-racket contact; implying the use of eye-head system. Players who employed predictive saccades did not attempt to fixate the ball after it bounced but rather fixated in the general vicinity of the ball; implying the use of image-retina system. Players initiated their backswing on average 260 msec (SD = ± 56) after the ball left the server's racket, whereas the foreswing was initiated some 220 msec (SD = ± 39) before ball arrival. Findings have implications for research as well as for training anticipation, selective attention and ball-tracking skills in tennis. In particular, future research should attempt to determine the relative effectivness of the image-retina and eye-head systems in tennis and whether the use of such strategies can be developed through appropriate visual training programmes.

TYPE A BEHAVIOUR IN SQUASH

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Certain vigorous activities, such as squash, can prove dangerous if the associated psychological reaction (e.g. competition, challenge) obscures symptoms which would normally limit an individual's effort (e.g. fatigue). Individuals with Type A behaviour patterns have been shown to seek out challenging situations and display excessive achievement strivings and cardiovascular strain in competitive environments (Glass, 1977: *Behaviour Patterns, Stress and Coronary Heart Disease*. New Jersey: Eslbaum; Jamieson and Lavoie, 1987: *Health Psychology*, **6**, 361-371; Theorell, 1974: *In Stressful Life Events: Their Nature and Effects* edited by B.S. Dohrenwend and B.P. Dohrenwend. New York: Wiley). The Type A behaviour pattern has also been linked retrospectively and prospectively with coronary heart disease (Review Panel on Coronary-prone Behaviour and CHD, 1981: *Circulation*, **63**, 1199-1215). The concern is that due to its extreme competitive environment, squash may prove particularly attractive to Type A individuals.

Two cross-sectional studies concerned with Type A behaviour in squash were conducted in order to:
(i) establish the profile of Type A behaviour in squash-players of differing standards;
(ii) investigate the relationship between Type A behaviour and physiological health and fitness measures in male squash-players.

The Jenkins Activity Survey (Jenkins, Rosenman and Zyzanski, 1974*: New England Journal of Medicine,* **23**, 1271-1275) was completed by 173 subjects allocated to 5 squash-playing competency groups; Sedentary, Recreational, Club, County and National. A sample of 31 male subjects from the squash-playing groups (Recreational, Club and Elite) were further tested for body composition (sum of 4 skinfolds), cardio-respiratory fitness (VO_2 corresponding to heart rate of 170 beats.min^{-1}) and blood lipid levels (HDL fractions).

A one-way analysis of covariance, using age and sex as covariates, yielded no differences in Type A behaviour between the Recreational, Club and Sedentary subjects. No evidence was therefore found to suggest that Type A individuals are more likely to gravitate towards squash. However, Type A behaviour was found to be more pronounced in the County group than the Sedentary, Recreation and Club groups ($p < 0.05$, $p < 0.001$ and $p < 0.05$ respectively). This would suggest that a self-selection process may be operating whereby the characteristics associated with the Type A behaviour pattern could prove beneficial for success in squash.

The physiological data revealed positive health and fitness profiles for all groups, with the elite group being superior. Type A behaviour was associated with higher physical fitness scores ($r = 0.447$, $p < 0.05$) and more positive HDL levels ($r = 0.436$, $p < 0.05$), both of which have been shown to be contra-indicators to coronary heart disease. It appears that enhanced physical fitness may be counteracting the negative cardiac health consequences of Type A behaviour in these groups. It is also possible that the physiological mechanism for the link between the Type A behaviour pattern and CHD may not be via serum cholesterol balance.

Analisys of psychological self-regulation techniques in critical situations during Table Tennis competitions

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In a high level Table Tennis competition, critical situations are those which may lead to an increase in psychic stress; at these moments, the player must be able to regulate his own behavior, aiming at mantaining a good level of performance. These critical situations in Table Tennis were investigated by HINDEL (1989), KROHNE & HINDEL (1992) and STRAUB & HINDEL (1993) which have identified the techniques that players use to overcome the psychic stress of such situations. The present study aims at investigating the most important critical situations in high level Table Tennis competitions. It also intends to analise the self-regulation techniques applied by the athletes, aiming at identifying which techniques are more effective at these situations through the result of the immediate two points after each situation. Five athletes from the Brazilian national female team took part in this study; they were between 16 and 22 years old and have been training Table Tennis for at least 6 years, with international experience. The 6 most important critical situations were choosen by 100 athletes and coaches through the "Critical Situations in Table Tennis" (CSTM) inventory, developed at the Laboratory of Sport Psychology in the Institute of Physical Education -Federal University of Minas Gerais. The situations occur when the player loses the point in the following circumstances: easy ball; service; return of service; third ball; long rally point; easy ball in a long rally point. Four national and international competitions were video recorded. The self-confrontation method were used to analyse the critical situations and self-regulation techniques. These were classified in motor, cognitive and combined techniques. The chi-square test was used to compare the self-regulation techniques and determine if statistical differences were found in the following two points. A total of 821 points were analysed and 237 critical situations were identified. It was determined that self-regulation techniques were applied in 105 critical situations; the frequency of application of each technique to each situation was also determined. The motor techniques of self-regulation were prevalent in 65,7% of all situations; cognitive techniques were applied in 9,5% of the situations and the combination of both motor and cognitive techniques were used in 24,8% of the situations. The comparison of the self-regulation techniques based on the result in the two following points, showed a statistical difference ($p=0,044$), with the cognitive techniques presenting better results, overcoming the motor and the combined techniques, which have no difference. The critical situations were also divided in two groups of three situations, the first being related to basic errors and the second to general errors. In this case it results indicated significant diferences in those basic errors ($P= 0,027$), with the motor techniques proving to be less efficient then cognitive or combined techniques. With the general errors, the motor and the combined techniques showed the higher value of lost points, when compared to cognitive techniques. It was not possible to evaluate the significance of this difference due to the low number of errors in these situations. The results suggest that the Table Tennis player must be prepared to use self-regulation techniques when facing critical situations in competition, and, in this present study, the cognitive techniques proved to be more efficient when one considers the immediate result after each critical situation. Other studies must be carried out in order to find out how individual and intercultural differences can modify the efficacy of these techniques, as well as, the self-perception of what is critical in a Table Tennis match.

Technical rehearsal and imagery: A model for enhancing technical skills in Table Tennis.

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Those involved in Table Tennis know that it is a sport with high technical demands and skills. In order to master the game hour after hour has to be spent on the table practising. The same methods and exercises has been used by coaches and players over the last decade. Therefore this work is an attempt to combine psychological and technical training into a new way of rehearsing and develop these Table Tennis skills. Richard Suinn (1985) developed in the 1980`s a method to rehearse sports skills. His Visual Motor Behavioural Rehearsal (VMBR) contains two steps: relaxation and imagery. VMBR plus aspects of Banduras (1975) theories of modelling conveys an insight into the rehearsal model in question. In former research the experimenter found connections between VMBR and modelling (Fallby, 1996). VMBR:s two steps and three more taken with support from Banduras modelling theory forms the content of this rehearsal model. The three steps added are observing video tapes, physical practice and direct feedback from the coach. These five steps together give us the following appearance in practice: (1) relaxation, (2) observing a video tape containing role models performing the technical detail we want to practice, (3) imagery where the athlete sees herself performing a perfect session of practice, (4) physical training, (5) direct feedback from the coach concerning the performance of the current practice session. The research is being carried out as a case study, with three elite Swedish Table Tennis players (24, 24 and 21 years old). Intervention is taking place in an A-B-A design with a one week baseline period, nine weeks of practising followed by four weeks baseline. Including introduction to imagery and relaxation for the participants, the project will have a total running time of 18 weeks. Performance measures used will be multi-ball training, self-assessments from players, assessment from the coach independent of players, interviews with the players and electromyography (EMG) testing before and after interventions. A model containing this protocol was conducted at the Halmstad University in a pilot study with four sessions of practice during four weeks. The involved players in the experiment group showed an increase in forehand top spin accuracy that was significantly higher than the control group. Furthermore did the experiment group estimate their technique and "touch" of the ball as improved, while the control group showed a decrease in their estimation (Fallby, 1995). In China a project involving a similar rehearsal model has been tried with the conclusion that the improvement in accuracy and technical quality of shots among 7-10 year old children clearly indicates that mental-imagery training can result in enhanced performance (Orlick, Zitzelberger, Zhang & Ma, 1991). With the Chinese project and the pilot study at hand, there is a good chance that the results from the research, can give interesting indications whether a technical practice method in table tennis can be developed.

Using performance profiles with a Regional Junior Table Tennis Squad

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Performance profiling was adapted by Butler (1989: In *The Psychology of Sport: Theory and Practice*, edited by J. Kremer and W. Crawford. BPS Northern Ireland Branch, Occasional Paper) from the work of Kelly (1955: *The Psychology of Personal Constructs.* New York: Norton) and may be used to help the athlete examine his or her current level of performance. The utility value of performance profiling in sport psychology has been consistently reported in racket sports (Jones, 1993: *The Sport Psychologist,* **7,** 160-172) and volleyball (Dale & Wrisberg, 1996: *The Sport Psychologist,* **10,** 261-277). The use of performance profiling with Junior athletes has not been reported. One-to-one consultancy sessions may be optimal within sport psychology, however certain constraints (financial, temporal and practical) can dictate that group sessions are more appropriate (Brewer & Shillinglaw, 1992: *The Sport Psychologist,* **6,** 139-147). The use of performance profiling as a baseline assessment tool enables a psychological skills training programme to focus on the areas which an athlete perceives as important. Similarly, by collating individual profiles of the squad, important common psychological themes may be identified for group sport psychology workshops.

The aim of this paper is to show the value of performance profiling as a baseline assessment tool for identifying Junior Table Tennis players' (n = 16, *Mean age* = 15 years, SD = 1.03 years) strengths and weaknesses and common psychological themes for sport psychology workshops in a group setting. Additionally, the coach's perceptions of the players' requirements were examined. The performance profile was produced following the group method identified by Butler and Hardy (1992: *The Sport Psychologist,* **6,** 253-264).

Individual performance profiles comprised different constructs and identified the perceived strengths and weaknesses of each of the players. An audit of all the performance profiles identified common psychological constructs. Constructs in which more than 50% of the squad identified discrepancies of 3 units or more between their ideal and self assessments were targeted for the group workshops namely; *concentration* (75% of players), *relaxed* (50%), *composed* (69%) and *positive attitude* (56%). The coach's assessment of the players requirements partially supported the players' self assessments. However, discrepancies were identified between how the coach construed individual players and how individual players construed themselves, suggesting the need for further discussion of their perceptions of performance (Dale & Wrisberg, 1996: *The Sport Psychologist,* **10,** 261-277). In summary, performance profiling identified perceived strengths and weaknesses for Junior Table Tennis players. Furthermore, individual profiles may be collated to identify common psychological themes for group sport psychology sessions.

Notational analysis of racket sports.

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Since research in notation was first published, the application of analysis to racket sports has remained at the forefront of this field. Early hand notation systems, in the mid seventies, demonstrated the possible potential of notation despite the relative complexity of most of these systems. One of the tennis systems was so complex it was never used, but the fundamental principles underlying its structure did pave the way for the transfer of some of the ideas into practical systems in squash and badminton. Even so these systems suffered from problems such as long learning times, as much as 5-8 hours, and there were even more difficulties in processing the data, over 40 person-hours for a system for squash. In addition, the presentation of the data was invariably difficult to understand - three dimensional computer graphics was still another decade away. The advent of the personal computer in the early eighties enabled an immediate transformation of some of the problems. As the machine memories increased and peripheral hardware improved then the problem of 'learning the system' could be simplified considerably. Colour graphics became readily available with computers in the mid eighties and, although user friendly software packages lagged some way behind, work progressed at making the data easier to understand for the coach and the athlete.

Considerable research has taken place throughout the eighties and nineties that has contributed to the overall understanding of racket sports. Match analysis, either in-event or post-event from video, involves gathering data from competitive performance whilst it is going on. As such it can always be termed ecologically valid and this is one of the greatest advantages over other forms of performance analysis in sports science. The applications and uses that have been advanced by this research thrust are :

* the need for, and benefits, of notation,
* analysis of technique and its application to
* tactics - definition of patterns of play.
* movement analysis,'
* creation of databases - modelling/prediction,
* motivation
* heightening awareness in players,
* investigating or suggesting changes in rules.

The developments in computing hardware and software are racing almost as fast as imagination. Interactive systems, integrating the video camera and recorder with the computer, voice interactive systems, computerised video-editing suites, miniature cameras (on helmets, hats, in stumps etc.), automatic individual identification and tracking systems, virtual reality viewers have all been possible for a decade. The use of these sophisticated advances will be used by NGB coaches over the next few years, but the most significant advances that are in the numbers of coaches, at all levels, that are using analysis, of different forms, with all their players.

A Match Analysis of Elite Tennis Strategy for Ladies Singles on Clay and Grass Surfaces

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This study compares elite tennis strategy in the ladies singles game on clay and grass surfaces. Points were classified as shown in table 1 and the *cause* and *effect* of players approaching the net were investigated. The *causes* of players approaching the net were classified as following up good serves or approach shots or attacking opponents serves, drop shots or short length shots. The *effects* of attacking the net were classified into the different ways points could be won at the net (volley, overhead, drive winner, drop shot and opponent error), the different ways points could be lost at the net (lobbed, passed or net error) and retreating from the net. The aim of this study was to investigate differences in the strategies adopted by ladies at the two tournaments. The data included 1006 points from 10 matches involving 13 different players from the 1996 French Open and 939 points from 11 matches involving 15 players from the 1996 Wimbledon Open. A computerised system allowed details of points to be captured and analysed. Table 1 shows the distribution of point types on both surfaces resulting from both first and second serves.

Table 1. Summary of analysis for first and second serves at the two tournaments.

Strategy	Roland Garros 1st Service		Roland Garros 2nd Service		Wimbledon 1st Service		Wimbledon 2nd Service	
	%points	%won by server	%points	%won by server	%points	%won by server	%points	%won by server
Ace	2.53%	100.00%	0.54%	100.00%	4.13%	100.00%	0.26%	100.00%
Double Fault	0.00%	0.00%	12.74%	0.00%	0.00%	0.00%	12.37%	0.00%
Serve Winner	16.43%	100.00%	10.57%	100.00%	19.57%	100.00%	13.95%	100.00%
Serve Return Winner	1.11%	0.00%	4.88%	0.00%	2.33%	0.00%	4.74%	0.00%
Server Attacks Net First	16.27%	65.05%	11.65%	55.81%	27.29%	59.87%	17.74%	60.71%
Receiver Attacks Net First	7.74%	32.65%	8.94%	39.39%	10.23%	38.60%	12.89%	44.90%
Baseline Rally	55.92%	51.69%	50.68%	51.87%	36.45%	49.26%	41.05%	47.44%
TOTAL	100.00%	60.98%	100.00%	47.43%	100.00%	61.94%	100.00%	48.42%

Similar percentages of points are won by the server on first and second serves on each surface. On clay, there are more baseline rallies and fewer points won on serve and at the net than on grass. The distribution of *effects* (outcomes) of approaching the net is similar on both surfaces when the server or receiver attacks the net. However, the *cause* of elite ladies approaching the net differs on the two surfaces. On clay, elite ladies are *drawn* to the net (by an opponents short ball or drop shot) on 49.12% of occasions, winning 58.93% of such points. On grass, they are *drawn* to the net on 14.65% of occasions, winning 71.73% of such points. Although a player loses less points at Roland Garros by *drawing* the opponent to the net than at Wimbledon, she still loses the majority of such points. The decision to adopt such a strategy depends on the player's and the opponent's current form at the baseline.

In the singles game, elite ladies tennis players should introduce the specific technical preparation into their training to support the necessary strategy to be adopted on the particular surface of the tournaments for which they are preparing.

Notational Analysis of Rallies in European Circuit Badminton

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A computerised system was developed to record rallies and shots in racket sports. Two observers were trained to operate the system and over a four match reliability study (using Ulster League Division One matches), inter-observer variation did not exceed 1.5% for the time recorded for rallies. During the reliability study, qualitative observation suggested that there were differences in shot tallies within the mens and ladies games. The purpose of this study was to investigate differences in shot tallies between singles and doubles in the mens and ladies games. Seventeen matches of the European Badminton Circuit tournament at Lisburn, Northern Ireland (5th-7th December 1996) involving elite players were analysed using the system. Table 1 summarises the results for mens and ladies singles and doubles.

Table 1. Summary of the shot and rally analysis of the different disciplines.

	Mens Singles	Ladies Singles	Mens Doubles	Ladies Doubles
No. Matches	4	4	5	4
Mean Rally Length (s)	9.15±0.43	6.73±1.25	6.35±1.39	7.61±1.81
% Rallies 0 to < 2 secs	4.29±2.69	1.88±3.25	27.65±3.49	16.42±3.44
% Rallies 2 to <4 secs	20.87±3.70	29.37±10.53	26.42±6.02	22.57±4.34
% Rallies 4 to <8 secs	30.83±3.32	39.75±4.47	21.28±3.64	28.73±8.28
% Rallies 8 to <16 secs	30.62±4.00	25.47±8.15	15.46±4.07	22.28±5.11
% Rallies >=16 secs	13.17±2.18	3.79±3.87	9.20±4.72	10.11±5.48
Mean Inter-Rally Length (s)	13.84±1.16	11.03±2.09	15.01±1.63	11.72±0.87
Shots per rally	9.20±0.82	5.85±1.28	8.55±1.67	8.98±1.69
Inter-shot time (s)	0.997±0.047	1.160±0.046	0.741±0.029	0.846±0.021
Shots per second	1.004±0.046	0.862±0.034	1.349±0.052	1.183±0.029

Mens singles rallies are significantly longer than those of ladies singles ($p<0.01$) and mens doubles ($p<0.01$). Male players take longer rest times than ladies in both singles ($p<0.05$) and doubles ($p<0.01$). The number of shots played per second are significantly greater for mens badminton than ladies for both singles ($p<0.01$) and doubles ($p<0.001$) play. Although the doubles games involve two people on each side of the net, shots do not always alternate between them. Therefore, the shorter inter-shot time for doubles requires greater reactions from the doubles player. Male players take significantly longer rest times than ladies in both singles ($p<0.05$) and doubles ($p<0.01$). There are significantly more rallies of less than two seconds in doubles than singles in both the mens game ($p<0.001$) and the ladies game ($p<0.001$). This reflects the greater number of rallies lost by the server in doubles due to the pressure of serving against two players.

There are differences in the singles and doubles games for both elite men and ladies. Therefore, badminton training should be specific to the particular disciplines. The timing information recorded for a match is also useful in practice as it can demonstrate to the player(s) lapses of concentration by the player(s) and the opponent(s) after long rallies. Other practical uses of timing results occur in the discussion of fatigue and how players should use the periods between rallies.

A DYNAMICAL ANALYSIS OF CHAMPIONSHIP SQUASH MATCH-PLAY

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We (McGarry and Franks, 1996) analyzed championship squash match-play for signature features of invariant athletic behaviour from a player's shot response(s) to various preceding conditions. The results led us to suggest that the dynamic nature of squash (sport) competition might be better analyzed at the level of process rather than product. It might be that the system (squash) might intermittently transit between states of invariant (stable) behaviour and variant (unstable) behaviour, and that system transitions arise as a result of spontaneous pattern generation in open (living) systems. The proposition that the system is perturbed by individual shot behaviours from a stable state to an unstable state, or vice versa, has already received support from a perceptual analysis by independent observers (McGarry, Khan and Franks, 1996). We now consider squash competition as a dyadic system and use dynamical principles to analyze the data for evidence of intermittent switching between different system states. Specifically, we posit that championship squash match-play can reasonably be considered as a pair of non-linearly coupled oscillators, not least since each player oscillates around the T-position (T) as he(she) competes for control of the rally. We thus analysed the phase relation between the two players (i.e.,the position of one player relative to the other), expressed as the radial distance from each player to the T at any instant. This was calculated from each player's, x-y coordinate data sampled at 10 Hz and recorded from a perceptual tracking in real time from videotape of the perceived centre of mass for four selected rallies. The radial data (see Figure 1a) show that, as expected, the system is tightly coupled for much of the time in anti-phase (e.g.,one player approaches the T as the other player leaves the T). A shift from anti-phase is observed at approximately 10 seconds, from which the system remains unsettled until the end of the rally. The shift from anti-phase may or may not reflect the system transition identified from a perceptual analysis by independent observers. The absolute data (Figure 1b) (i.e.,the distance between the two players at any instant) in this example show periodic system shifts between two system states although an oscillatory component is observed in two of the other three rallies. These results provide a first pass at analysing championship squash match-play as a dynamical system. It seems that important information in the context of sport competition might be conveyed in the phase relation between two players and that a formal system description of sport (squash) competition in accord with dynamical principles warrants further exposition.

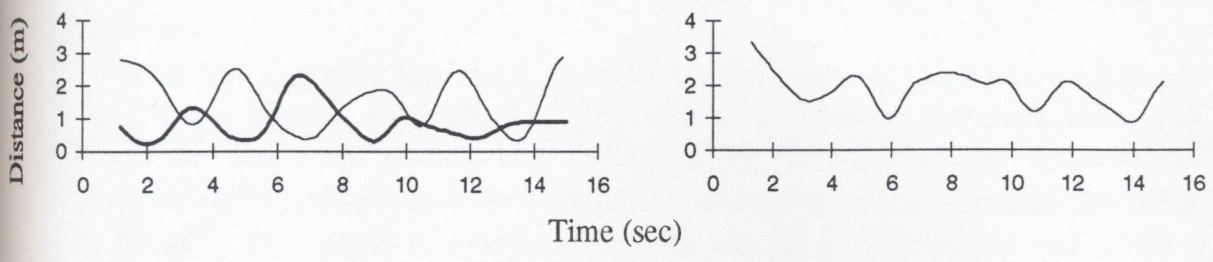

Figure 1. (a)Radial distance from T for the server (bold) and the receiver (normal). (b)Absolute distance between the server and the receiver. Data sampled at 10 Hz.

THE INFLUENCE OF SERVICE ON THE POINT PROGRESSION IN DIFFERENT PLAYING STYLES

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The service plays a significant role in the progression and the ending of the point. The purpose of this study was to analyse the matches of the Greek National Table Tennis Team players according to service, during the Greek National Table Tennis Championship 1994-1995, in order to investigate the relation of service on the point progression in different playing styles.

The matches of the 5 best National Table Tennis Team players were video-recorded. The winning and the losing points, after execution or receiving services, were classified in categories according to a specific recording form. The results were analysed in percentage basis in order to be comparable.

The offensive players based upon their services (59.48%) to win the point until the 3rd ball (third ball attack). On the contrary the defensive player based upon the long duration of the point (59.52%). The offensive players, after the execution of the service, win or lose the point until the 3rd ball (58.16%) while when they receive services win or lose the point until the 4th ball (65.21%). The correlative percentages for the defensive player are 39.81% and 45.2%.

The service is the main tactic of the offensive players and helps them to win the point until the 4th ball. On the contrary the defensive players based mainly upon their good control of the ball during the point.

Further research will be done in order to investigate the influence of service in the performance profile of the table tennis players.

Key words: Service, Tactics, Table Tennis.

A STUDY ON MOVEMENT TRAINING METHODS FOR JUVENILE TABLE TENNIS PLAYERS

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Movement is an important part of the technique of striking the ball. If a table tennis player possesses good footwork, the player will seize the hitting position promptly (in the match), bring into play the winning essential factors of batting speed, spin and power, and lay a foundation for gaining the initiative and victory. According to the principles of the science of sports training, the program of table tennis teaching training and some related subjects, this work has developed a set of testing contents and targets for juvenile table tennis players' footwork flexibility.

This study has taken two steps of experiment training, chosen ten targets (four kinds of many-ball training, four kinds of fitness and two kinds of body function) as objective basis of reflecting juvenile table tennis players' footwork flexibility. Many-ball training is the effective method of developing juvenlie table tennis players' footwork flexibility (FF); different way of offering ball will get different effect of developing subjects' FF. The way of ordered offering ball is good for subjects to master the methods of moving footwork and make a basis for further improving. After subjects possess some trained foundation, the way of disordered offering ball is more effective to develop subjects' FF than that of ordered offering ball, and the way of disordered offering ball is advantageous to link up actual combat. Comparing the methods of many-all training, the disordered group got more striking effect than the ordered group, and the differences of the four many-ball training targets got to 0.01 level. From the training datums, we can use them as the ration datums to train the same juvenile table tennis players' footwork flexibility.

After testing players aged ten to fourteen, the data showed: 1) Developing juvenile table tennis players' footwork flexibility should be done at the same time with developing fitness and function level.2)When taking many-ball training, different way of supplying-ball will obtain different results of developing trainees' footwork flexibility. 3) It's good for trainees to master quickly the way of foot movement and to lay a foundation for further improvement by using ordered way of supplying-ball.4) Disordered way of supplying-ball is advantageous for trainees to make a further development of their footwork flexibility and to combine with actual match.

Key word: juvenile table tennis players, footwork, footwork flexibility

STUDY OF THE PROBLEMS OF CHINESE UNIVERSITY STUDENTS' TABLE TENNIS OPTIONAL COURSE TEACHING METNODS

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China is one of the strongest countries of table tennis in the world. This achievement should be connected with the education of Physical Education in university. The skill level of Chinese university students towards table tennis has got an important meaning to keep and improve Chinese "Table Tennis Population" and skill level. So mainly adopting the method of educational experiment, this paper studied the problems such as "Table Tennis Optional Course Structure, teaching contents teaching methods and measure of Chinese University". During the experiment, this paper compiled the contents of teaching material fixed in Teaching Programme into teaching procedure; designed and carried out the determination and marking method of two kinds of programmed learning and three sorts of table tennis basic skill targets. Basically we achieved the goal of evaluating teaching resultswith rationing method, which caused the test marking-method of table tennis skill make some progresses. The experiment shows: The hypothesis doesn't exist, of which two kinds of programmed leanings would produce different teaching results (The difference between them is below 0.05 level.). That is: With the same teaching condition, the two kinds of programmed leanings have the same meaning of effectiveness and practicality. It also means that the teaching results achieved by taking two kinds of teaching methods are nearly the same. After making further comparing and analyzing, we know that as for those complicated action structure of teaching and highly-requested skill, taking the style of "Passing learning Steps" teaching method will get better results, while as for the skill of some simple action structure, it's better to take the style of "Each lesson with a new content" teaching method. Through experiment, we also found that the same and different points of these two kinks of programmed leanings their strong points and shortcoming will offer more detailed information and material for widening the teaching methods and means of table tennis optional course of Chinese students who are facing the 21th century.

Key words: table tennis optional course, programmed learning, teaching methods, teaching results

A Notational Analysis of Time Factors of Elite Mens and Ladies Singles Tennis on Clay and Grass Surfaces

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The purpose of this study is to complete a time analysis of singles tennis at the French and Wimbledon Open Championships of 1996. The reason for the study stems from the introduction of a slower ball at Wimbledon and a faster ball at Roland Garros. The grass surface of Wimbledon is faster than the clay surface of Roland Garros. The purpose of this study was to determine whether the introduction of the new balls had resulted in similar games on the two surfaces. A computerised timing system allowed the timing distributions of rally, inter-service, inter-point and inter-game times to be measured. An inter-observer reliability study was conducted on the first set of the ladies final of the French Open using Method Errors (ME) and Intra-class Coefficient Correlations (ICC) (Rallies ME=1.71%, ICC=0.9932; Inter-Serve ME=0.83%, ICC=0.9969; Inter-Point ME=0.46%, ICC=0.9997). In total, over 55 hours of tennis were analysed and the results are presented in the table 1.

Table 1. Summary of analysis of ladies and mens singles at the two tournaments.

	French Ladies	Wimbledon Ladies	French Mens	Wimbledon Mens
Matches Analysed	10	11	9	14
Players Involved	13	15	11	15
Hours of Play Analysed (hrs)	10:33:33	9:17:44	19:25:45	15:44:08
Number of Rallies Analysed	1006	939	1859	1768
Rally Time (s)	8.05±6.14	5.99±4.33	5.64± 4.69	3.69±2.54
Inter Serve Time (s)	10.38±2.76	10.60±3.26	10.13±3.63	10.53±2.49
Inter Point Time (s)	19.53±6.30	19.17±5.36	19.96±5.44	18.42±5.33
Inter Game-same ends (s)	28.12±5.96	27.43±6.02	28.11±5.61	27.15±5.47
Inter Game-change ends (s)	100.08±18.30	94.14±32.91	102.91±10.74	84.12±9.32
%Match playing rallies	21.30%	16.81%	14.99%	11.52%

Despite the introduction of different balls at the two tournaments, rallies are significantly longer on clay for both mens ($p<0.001$) and ladies ($p<0.01$) singles. The proportion of the match spent playing rallies is also longer on clay than grass. Rallies in ladies singles are significantly longer than in mens singles on both clay ($p<0.001$) and grass ($p<0.001$). The mean mens singles rally length of 3.69 seconds at Wimbledon is longer than the mean reported for the 1992 Wimbledon Championships of 2.52 seconds (Hughes, M. and Clarke, S., "Surface Effect on Elite Tennis Strategy, in *Science and Racket Sports*, (editors: Reilly, T., Hughes, M. and Lees, A.), E & F.N. Spon, 1995, 272-277). Therefore, the ball change at Wimbledon has resulted in longer rallies, but rally lengths are shorter than at Roland Garros. The mean mens rally length at Roland Garros is also longer than the 1992 mean for the Australian Open of 4.87 seconds reported by Hughes and Clarke (1995). This is evidence that despite the ball change at the French Open, rallies in the mens singles game are longer at Roland Garros than at Wimbledon and the Australian Open.

42 Reliability and validity of a computer based notational analysis system for competitive table tennis

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In recent years computer based notational analysis systems have been developed for the objective analysis of performance in a range of sporting activities. Table tennis at the highest level is a physically and technically demanding sport, where the application of quantitative feedback can be utilised by players and coaches to enhance performance. This study evaluated the reliability and concurrent validity of a computerised notational analysis system designed specifically for use in table tennis.

In developing the notational analysis system, all permutations of descriptors for table tennis shots were assimilated. This followed detailed discussions with national league players and coaches, and, careful analysis of video footage and computer programmes written for notation and analysis. The final system was Windows© based, with data being entered using the 'Mouse', via a graphical representation of a table tennis table.

Six national league matches were video recorded for subsequent analysis. The video camera was set up along the net line of the table, the camera view allowing for film to be collected to a minimum of 3 metres behind the end lines of the table.

Inter-tester reliability for the system was determined by 2 independent observers notating 6 games, randomly sampled from the 6 matches. Intra-tester reliability was evaluated by one of the observers re-notating the 6 games. The 2 observers were familiarised with the system through practice sessions with an experienced coach and an individual involved in the system design present. Inter and intra tester reliability was calculated for all observed sections of the game using Cronbach's alpha coefficient. An alpha value of 0.6 was the criterion level for acceptable reliability (Weiss et al., 1985). Inter-tester reliability calculated for the system as a whole was acceptable (α = 0.68), although values for individual components ranged from 0.40 (service type) to 0.91 (rally shot details). Intra-tester results ranged from 0.86 (rally shot movements) to 0.98 (rally shot details and end of rally details) with an overall mean value for the system of 0.95.

Concurrent validity of the system was evaluated by comparing results from the 6 computer notated games with data for the same 6 games hand notated by an experienced international coach. The validity of the computerised system as against the data from the 'expert coach' was determined using a measure of overall percentage agreement - the ratio of observed agreement to total number of observations from which the agreements were taken. Overall percentage agreement was 95.2%, far in excess of the 80% acceptable limit proposed for this method by Rushall (1977).

The results of this study show the computer based notation system to be both reliable and valid when data is inputted by individuals with significant experience of table tennis. Questions are raised however over the validity of inputted data and subsequent analysis from persons who are not experienced in the sport. Future developments relating to notational analysis should not only consider the descriptors in the specific system but also the training and experience of observers.

The Advantages of Left-handed Players in Table Tennis

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Abstract Top left-handed players have achieved striking results in world table tennis championships or Olympic Games. The quick and fierce style of left-handed players finds expression in four aspects. 1) Quick strike of the ball, high speed and a fast pace. Left-handed players enjoy a better sense of vision, space perception and intuition. Though both the right and left hemispheres are involved in motion, the former excels in space perception and intuition and the latter in logical thinking. Due to the asymmetrical division, the right hemisphere's control over the motion of the left hand is achieved through direct time and space perception when excited by incoming messages. Directness and high speed are typical of its perception, similar to the fast-signal phenomenon of impulse-inducing motion, hence fast impulse conduction. The left hemisphere, however, weighs the target, plan and effect of motion carefully. It uses space proprioperception of the right hemisphere to judge direction, and after logical thinking sends it back to itself to control the motion of the right hand, hence slow impulse conduction. A subtle time difference results between the hands in motion signal perception and response. Thus, in a high-level competitive state, left-handed players have a clear advantage of speed by their quick strike of the ball and fast pace. 2) Fierceness. In table tennis today stressing change and confrontation, left-handed players are noted for their fierceness. Top left-handed players excel in service and after-service attacks, and threat their rival with conscious, frequent forehand strike, lift or drive. Physiologically, the right hemisphere is associated with mood and intuition, so left-handed players are easily excited. With heredity-training coordination and stimulated by the competitive atmosphere and the coming ball, they are excited and full of strong impulses. 3) Striking the ball using the same action with a different hand may result in reverse spins or reverse directions of rebound and arc. The path of the part of a spinning ball with maximum surface line speed is often an atypical spin. As a result, service and arc from the same action with reverse spins weaken the right hand, which must temporarily busy itself with judgment, footwork, the angle of the bat, power and arc. 4) Left-handed players usually play at a sharp angle with cross-court shots, so the motion sphere becomes greater for the right hand, with technical and tactical difficulty in backhand remedy. The conclusions come from the author's coach work and experience of training the ex-champion Cai, a left-handed player, confirming that the findings are well-based and accurate. Penhold grip and hand-shake grip with either hand promote competition between the left and right hands, and will raise the quality of table tennis as a sport to a new level. Against left-handed players, four technical or tactical strategies can be adopted. 1) Improve conscious restriction and counter-restriction of the first four bats. The restriction conflict will become more evident. It must be borne in mind that the same action may result in reverse spins when combining service with pace and service with placement. 2) Improve the combination of service and attack choice with paths of the ball and pace during the fifth and sixth bats. 3) Variegate the means of backhand attack, defense and breakthrough, and bring forehand or pivot lift and drive to maximum play. Low-ball attack, backhand lift and pen-hold grip in a hand-shake grip style also help to recover from the awkward position. 4) Take advantage of their weakness, and without rule violation, induce their passive psychological factors. For if the right hemisphere lacks training in logical thinking, overridden by perceptual thinking, they can fall into a psychological or technical disadvantage.

The effect of computerised analysis as feedback on performance of elite squash players.

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The effect of feedback has been of great interest to sports scientists for many years and is still in its comparative youth today. Brown and Hughes (1995; In **Science and Racket Sports.** London:E. & F. N. Spon, pp. 232-237.) completed a similar study to this using different standards of junior players. They obtained mixed results with half the population of group showing a significant change in performance ($p < 0.05$). Their design was limited by the fact that they used adolescent players and the results were compromised by the effects of maturation. This study followed a similar format and examined the change in ability to react to feedback between elite players (N=4), ranked in the top 10 in Wales, and sub-elite (N=4) players, ranked between 10 and 30 in Wales. There are few numbers of athletes at this standard of performance and this consequently precluded the use of a control group, so this study was a comparative case study. The aim of the study was analyse the effect that detailed computerised feedback had on a group of elite standard squash players.

The subjects' play was recorded during a series of competitive matches (N=4) at the start of the study (T1). These matches formed the basis of the initial feedback. Over the next eight weeks, matchplay for each of the players was video-taped and computerised analysis and video feedback provided, combined with specific on-court practices and training (designed around the findings of T1). Finally, a second series of competitive matches (N=4) were recorded and analysed (T2). By comparing the results of T1 and T2 differences in performance could be recorded. Training diaries during the feedback time were kept and psychological (SPSQ) questionnaires were administered at the beginning of T1 and T2.

The study found very little change in the amount of errors played by the elite group ($P > 0.05$), however a there was a significant change in the amount of winners played by this group ($P < 0.05$). There was an increase in the amount of winners played for three of the four subjects played ($P < 0.05$), however, only one of the subjects found a significant decrease ($P < 0.05$) in the number of errors played. There was evidence from the questionnaires that there was a change in psychological states of the individuals between the two tests which apparently had an affect on performance. Also, those subjects showing a de-motivated state of mind also spent less time on the court which again will have affected performance. The specific areas of the court and specific shots, initially defined by T1, that the subjects needed to work on, indicated a slight improvement. Due to the interpersonal nature of group, they were all competing on the same university and national ranking ladder, it was recognised retrospectively an increase in performance of all the subjects was unlikely due to their mutual interaction, both in terms of performance and psychologically.

The attitudes, from the questionnaires and the training diaries, of the sub-elite group were not so ambitious nor dedicated as those of the elite players. Their sport was, it would seem, more of a social vehicle, although all did play and train most days. Nevertheless 3 of the 4 showed significant increases in winners and significant decreases in errors ($P < 0.05$), the other having a significant decrease in errors ($P < 0.05$). Although there were changes in the respective rankings of these players

during the season, it did not effect their attitude and frequency of training and playing in the same way as that of one of the elite players.

It was concluded that the feedback did have very positive effects on the performance of the two groups of players, despite the interaction effects now realised as inevitable in highly motivated athletes of this level. These interaction effects raise serious questions for coaches working with individual performance athletes in squads and groups at this level.

Notational analysis of tactics used by top under-18 junior tennis players from Britain and four other leading countries.

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There is a lack of research in the analysis of match tactics and patterns of play within tennis. Hughes and Clarke (1985; Surface effects in tennis. In **Science and Racket Sports**, London: E. & F. N. Spon, pp. 272-277.) concentrated on the different types of surfaces and whether or not the serve is as effective on all weather courts as it is on grass. Other studies in tennis have included the difference between the women's game and the men's game. British juniors manage to compete well with their counterparts from the rest of the world but this success does not extend into the senior ranks. To try to investigate whether this is a function of the patterns of play adopted by British , the aim of this study was to compare the patterns of play of top world ranked juniors to highlight differences of development.

It was decided to analyse patterns of play among elite U.18 junior players from Britain and compare these to the patterns of play other elite U.18 players from other countries. The data was gathered post-event from video which were taken from the two current National Tournaments held just before Wimbledon, they were the I.T.F. Group 2 Tournament held at Imber Court, London and the I.T.F. Group 1 Tournament held in Roehampton, London. Both of these tournaments enabled recording of some of the best juniors in the world. They were subdivided into the following groups:- British juniors (N=6), European juniors (N=6) and American juniors (N=3).

A hand notation system was designed to collect the data. It was validated for inter- and intra-observer reliability (97% and 98.5% respectively). Once the data was collected, 500 rallies were randomly selected from each group and processed analysing all the shots individually with respect to court position, the whole of the rally structure and the eventual outcomes Chi-square and t-tests statistical processes were used to assess significant differences in the comparison of the two sets of data.

Table 1. The distribution of shots across the tennis court for the three groups.

Court Position	British juniors	European juniors	American juniors
Front right	77	21	37
Front left	82	40	38
Back right	352	314	345
Back left	349	403	353

The British juniors differed in their patterns of play, playing significantly more shots at the front of the court ($P<0.05$). There were significant differences in the totals of winners and errors ($P<0.05$), the British players having the worse profile. The British players had a significantly greater frequency of hitting forehands instead of backhands in that area of the court ($P<0.05$), and not surprisingly hit significantly greater numbers of errors. European hit the highest number of attacking shots from the back of the court, British players hit the most defensive shots from that section. British players also had the lowest frequency of passing shots ($P<0.05$).

It is concluded that there are significant differences in the patterns of play by British junior players when compared to other top juniors from other countries. The template provided by this research defines the technical and tactical shortcomings of the British players, which should enable coaches to plan their training and practises accordingly for future elite players.

Movement Analysis of Elite Level Male Serve and Volley Tennis Players.

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In tennis players will often 'run round' a shot to change the ball to their favoured side, this is never done at elite level in squash or badminton because of the speed of the game at the highest levels. This inefficient movement will have a deleterious effect upon the recovery of the player back to a central position on the court. Previous notational analysis research in racket sports has mainly concentrated on playing patterns, time motion analysis has been completed on squash and badminton (Hughes, M. ,1995; Computerised Notation of Racket Sports. In **Science and Racket Sports,** London:E. & F. N. Spon, pp. 249-256), but none has been completed on tennis. The aim of this study is to investigate whether these inefficient movements have an effect on the ends of rally results. It is also intended that the study will broaden the existing research in movement analysis by providing a framework of the basic footwork movements of the tennis player, in preparation for the shot, at impact and during recovery. This study was limited to analysing the movement of elite male tennis players who use the 'serve and volley' game, in an attempt to eliminate subjects' fundamental playing differences as a dependent variable affecting the conclusions. The purpose of the hand notation system was to define successful footwork patterns in 'serve and volleys', pre-shot (skipchecks, ready positions), during impact (ground contact) and in recovery (speed of change of direction).

A hand notation system was designed to record the relevant aspects of movement and footwork patterns that will satisfy the aims of the study. The system allows the user to record background information about the match: the players; the tournament; the scores at the start and finish of the section of notation; the video cassette and counter number on which the match is stored, to facilitate retrieval of the game if necessary. A simple box and column system was used to record the server, and the score at the start of every point. The column adjacent was then used to record the movement patterns by letters and symbols. These notate the skipckeck, ready position on court, the use of ground contact or jumping just prior to impact with the ball, the shot played, the number of steps taken in an disadvantageous direction (i.e. away from the centre of the court) before changing direction, and the effectiveness of the shot. A validation study, notating the same set of play, at the same time of day, with one week's intervening rest period gave an intra-observer reliability to be 99.05%.
Seven matches in total were notated, providing fourteen movement performances as data for analysis, as each match was notated for both players. By concentrating on a small sample of eight players playing in the quarter-finals of Wimbledon, and beyond, ensured the very highest standard of players available for the sample population of the study.

The average number of shots per rally was 2.97 (2255 shots in 759 rallies), this compares closely to the figure of 3.09 obtained by Hughes and Clark (1995; Surface effect on elite tennis strategy. In **Science and Racket Sports,** London:E. & F. N. Spon, pp. 272-277). There were a small percentage (3.7%) of occasions when the player did not regain the 'ready' position, which was operationally defined as not being fixed relative to the court but varying with respect to the angle of the impending shot due to ball position. Taking paces through the shot and moving away from the centre

of the court was more common (8.4%), as was jumping through the shot (7.2%). These 'inefficient' aspects of movements, the mean number of steps taken per shot correlated highly with losing the rally (R = -0.88).

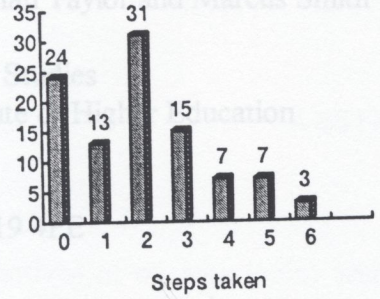

Fig. 1. The percentage of frequency of outright opposition winners plotted against the number of steps taken in playing the preceding shot.

Winning players averaged 0.348 steps per shot away from the centre of the court, whereas losing players averaged 0.384, although this was not significantly different at the 5% level. In addition there were no significant differences when comparison was made between winning and losing players for frequencies of 'skipcheck' and 'jump through'.

It was concluded that efficiency of movement in tennis was far higher than expected, but when players did run or jump through their shots then this did place pressure on them which resulted in their often losing the rally. It is suggested that sequences of these movements could provide a useful extension to this study, a sufficiently large database would have to be gathered and analysed to enable the complex statistics to be satisfactorily analysed.

THE EFFECT OF CARBOHYDRATE INGESTION ON SHOT ACCURACY DURING A CONDITIONED SQUASH MATCH

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ABSTRACT

The aim of the investigation is to ascertain whether the ingestion of a glucose polymer solution affects the maintenance of shot accuracy during a squash match consisting of three games. The participants were eight good club standard male players. The task consisted of playing two conditioned matches, each of three games duration. Prior to a self selected warm-up subjects consumed either 50% of a carbohydrate (CHO) solution (8.0g $100ml^{-1}$ kg^{-1} body mass, CHO-trial) or a similarly flavoured solution containing no carbohydrate (Placebo, P-trial). The remaining 50% of the respective solutions were consumed during the match. The order of the two games was counterbalanced among participants. Two performance accuracy tests were taken, the first after a 5 minute warm-up, and before game one, the second immediately after game 3. Measures of heart rate and ratings of perceived exertion (Borg RPE) were also taken at points during each of the games. The data were analysed by a series of 2-way Anovas (condition x game) with repeated measures on both factors. For the accuracy tests there was a significant condition x game interaction effect ($F_{1,7}$=12.4, P<0.01), and a significant main effect of condition ($F_{1,7}$=63.0, P<0.001). The mean number of points scored in the (CHO-trial) were 62.6 (±9.8) pre-game 1 and 60.6 (±11.6) points post-game 3. For the (P-trial) the figures were 59.1 (±8.7) and 47.6 (±8.4) respectively. The main effect of game failed to reach significance. Follow up Tukey analysis showed a significant effect on accuracy performance in the (P-trial) (P<.01). The heart rate data showed no significant effects at any level. When RPE scores were analysed, a significant interaction effect, game x condition, was found ($F_{2,14}$=10.4, P<0.01). There was also a significant main effect of game ($F_{2,14}$=150.8, P<0.001), and a significant main effect of condition ($F_{1,7}$=6.3, P<0.05). In the (CHO-trial) the mean RPE score was 12.2 (±.89) following game 1, and 14.7 (±.92) following game 3. For the (P-trial) the results were 12.7 (±.93) and 16.1 (±1.2) respectively. Follow up Tukey analysis indicated a significant difference between games 1 and 3 of the (CHO-trial), and between all games of the (P-trial) (P<0.05). The results support the conclusion that CHO ingestion promoted the maintenance of accuracy in squash, and also aided participants' perceptions of exertion over match conditions lasting up to three games. Investigation into matches lasting up to the maximum of five games is recommended.

REASONS FOR PARTICIPATION AMONG

ELITE JUNIOR TENNIS AND TABLE TENNIS PLAYERS

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ABSTRACT

Participation motives of 65 elite junior tennis players competing at the National Junior Hard Court Championships at Nottingham and 13 elite junior table tennis players at training centres in the North West were assessed.

The Tennis subjects were county, regional and national representative players in a large national competition. The standard players attending one of three elite training centres in the North West Region.

A participation motivation questionnaire devised, validated and factor analysed by Gill, D., Gross, J. and Huddleston, S. (1983) was used to gather data on sport, gender and age group. There were 29 items that respondents ticked on a 5 point Likert scale. A three way analysis of variance was used to examine the effects of sport, gender and age on each of the 29 items. The age groups were under 14 and under 18 years, which were the ones used at the National Tennis Championships.

Significant group differences were found on three items. It was found that Tennis players scored higher on need to win [$F_{1,73}=4.59$ ($P<0.05$)], to compete [$F_{1,76}=5.96$ ($P<0.05$)], and play as a team [$F_{1,76}=5.25$ ($P<0.05$)].

by contrast parental support was perceived as much stronger for the table tennis players [$F_{1,75}=11.03$ ($P<0.01$)]. there was a gender by group interaction on the response to coaches, with female Tennis players and male Table Tennis players keener on their coaches [$F_{1,71}=4.07$ ($P<0.05$)].

The response to the question on parental support showed an interaction of group with age. The younger Tennis players scored higher on parental support, whereas the Table Tennis players scored higher as they reached their later teens.

These results should be treated with caution owing to the small number of table tennis subjects.

Further investigation of the underlying reasons for these responses is needed, and more Table Tennis subjects need to be tested.

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A preliminary investigation into Trait Anxiety levels of Chinese Table Tennis Players.

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Adopting the State/Trait Anxiety Inventory developed by Speilberger (1966), the researchers assessed the trait anxiety and state anxiety of 42 male and female Table Tennis players who were participants in the Chinese National Table Tennis Championships. The experimenters adapted the Speilberger Inventory for use with Chinese subjects. Both the state and trait forms of the questionnaire were administered to the players on non-competition days and competition days. Results indicated that the state anxiety level increased significantly before the contest ($p<0.01$), whereas trait anxiety levels among the various ranks of players. However, elite players tended to be lower on state anxiety than second grade players. In conclusion it was found that Table Tennis players' state anxiety increases significantly before matches. It is suggested that since state anxiety may be a characteristic which can distinguish between good and bad performance, that it may be important for coaches to help players to control and adjust their anxiety level.

Stress and Arousal in Elite Youth Badminton Players: A Reversal Theory Perspective

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Kerr (1987) suggests that the relationship between arousal and performance is critical to elite sports performance and offers Reversal Theory as a framework for investigating this relationship. Reversal Theory proposes that discrepancies between the performer's current level of arousal and the level they would prefer to feel are detrimental to performance and will result in negative affect. Tension stress (deriving from internal or external factors) results from this affective response and internal or external effort stress is experienced in attempts to combat tension stress. Discrepancies between tension and effort stress are also expected to adversely affect performance (Males & Kerr, 1996). In support of this, Cox & Kerr (1989) found greater arousal discrepancies associated with losing than winning squash players and Males & Kerr (1996) revealed null arousal discrepancy prior to slalom canoeists' best performances. However, they found a significant arousal discrepancy prior to only one subject's worst performance. Similarly, the discrepancy between tension and effort stress was only significant prior to one subject's worst performance. Faced with these equivocal findings, this study examined relationships between arousal and stress discrepancies and objective and subjective performance outcomes. Subjects were 16 elite youth badminton players participating in a tournament as part of a residential 'High Performance Badminton Camp'. Prior to each game subjects completed the Telic State Measure (Svebak & Murgatroyd, 1985) and sections of the Tension Effort Stress Inventory (Svebak, 1993) to provide measures of felt and desired arousal levels and internal and external tension and effort stress. Absolute arousal and stress discrepancies were calculated and subjects indicated how satisfied they were with their performance in each game on a 7 point Likert scale. This rating was operationally defined as the individual's subjective performance outcome and two groups were formed based on the subjects' reported levels of satisfaction: 'satisfied' and, 'dissatisfied'. Objective outcome was defined as either 'win' or 'loss'. Contrary to predictions, losers did not experience greater pre-game arousal or stress discrepancy than winners and dissatisfied players did not experience more internal stress discrepancy than satisfied players ($p > 0.05$). However, dissatisfied players reported significantly greater arousal discrepancy [$Z = -2.8966$, $p < 0.01$] and external stress discrepancy than satisfied players [$Z = -1.74743$, $p = 0.06$]. It appears that if players are to achieve performances with which they are personally satisfied, felt arousal level should match the individual's preferred level of arousal which underscores the importance of individualised psychological interventions. These results also suggest that external stressors may influence performance satisfaction via the misapplication of coping effort or because the athlete is 'trying too hard' to cope with perceived external stressors. Future research should further explore external sources of stress in young athletes and should identify suitable intervention strategies for dealing with this phenomenon and helping young athletes gain maximum satisfaction from their sporting experience. This is particularly important in maintaining participation levels in young athletes.

Perceptions of the direction of multidimensional state anxiety during performance in elite and non-elite male tennis players

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Abstract

This study examined the multidimensional (direction) anxiety perceptions of elite (n=4) and non-elite (n=4) male tennis players, and explored how these perceptions were thought to influence performance in core skills. Retrospective interviews were carried out, focusing on the players' perceptions of '*in vivo*' anxiety and self-confidence states. In line with established protocol (Côté, Salmela, Baria & Russell 1993; Gould, Eklund & Jackson, 1992) the qualitative data was subjected to content and frequency analysis.

Results identified two major findings. Firstly, on a global performance level elite players elicited more facilitative cognitive and somatic higher order sub-themes than non-elite players. However, elite players also reported a considerable number of debilitative higher order sub-themes. Both elite and non-elite players identified a greater number of high self-confidence higher order sub-themes than low self-confidence higher order sub-themes.

Finally, perceived direction of anxiety and self-confidence was also noted to have a differentiated impact on the tennis players' core skills (*e.g.* forehand, backhand, volley).

These findings illustrate the benefits of using qualitative research in obtaining rich and meaningful data. They also partially support earlier work (*e.g.* Jones, Hanton & Swain, 1994) which suggest that elite athletes perceive their anxiety as more facilitative and experience higher self-confidence compared to non-elite athletes. Furthermore, these findings suggest that anxiety and self-confidence perceptions influence the players' execution of techniques.

GAME PERFORMANCE AND GAME UNDERSTANDING IN BADMINTON OF FINNISH PRIMARY SCHOOL CHILDREN

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Abstract

Game performance can be divided into cognitive and skill components. The cognitive component includes decision making and knowledge, whereas the skill component includes motor execution. Quality of decision making in a game situation is often as important as execution of the motor skills, and both of these determine successful performance in sport (Thomas 1994). The relationship between cognition and motor skill is important in the development of skilled sport performance in young children. However, it has been shown that the development of cognitive skills progress at a faster rate than the development of motor skills (Thomas et al. 1988).

The purpose of this preliminary study was to examine game understanding and game performance in badminton. Primary school children (boys N=10 and girls N=10) in two different age groups (9-10 and 12-13 years) served as subjects. First the subjects played singles badminton 2 x 5 minutes. All matches were video recorded and analysed using SAGE Game Manager for badminton software. Game understanding of the subjects was studied with 19 different video sequences which were simulations of actual badminton situations. In the video test the subjects had to decide in ten seconds, from three different response options, what they would do in the different situations and then to argue for their decisions. Percentage calculations and chi-square test were used for statistical analysis.

Table 1 shows that the scores of the video test were almost the same between age groups and gender. The match analysis revealed that there were some differences in game performance between age and gender groups. The total amount of shots, the percentage of clears and

Gender	Age	Video test score	Total amount of shots	Successful shots (%)	Amount of serves (%)	Amount of clears (%)	Amount of errors (%)	Effective playing time (%)
Boys	9-10	56	297	80	49	36	14	22
	12-13	56	588	90	20	51	9	49
Girls	9-10	52	345	79	42	37	20	28
	12-13	62	484	92	21	60	8	46

effective playing time was greater in the age group 12-13 years and the percentage of serves and errors was greater in the age group 9-10 years.

The results indicated that the younger subjects played shorter rallies than the older ones. This could be due to their lower skill level in badminton. The scores of the game understanding test implied that the younger subjects had already developed their game understanding almost to the level of the older subjects even though their game performance did not reach the level of the older subjects.

In conclusion it can be said that the basic tactical ideas in badminton are quite easy to understand, although it is difficult, at least for the younger children, to keep the ball alive in actual game play. From the tactical perspective it would be important to use modified games in teaching the basic tactical concepts for younger children because in these games the lower skill level does not restrict the use of their tactical knowledge.

The Travelling Racket Sports Player

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Professional rackets sports players nowadays are engaged in competitive circuits that demand frequent transworld travel. This presents psychological and physiological stresses; the former are associated with hassles and fatigue of travelling, the latter with body clock disturbances and environmental influences. The psychological stresses can be eased by systematic organisation and planning. The physiological disturbances are inevitable when multiple time-zones are crossed and when climatic conditions are different in the country visited.

The body clock disturbances give rise to the syndrome of jet lag. This persists for some days until the body's circadian rhythms return to their normal phase and harmonise with the new environment. The severity and duration of jet lag symptoms are greater following eastward than after westward travel. Younger and fitter individuals cope better with jet-lag than the older and less active individuals. Behavioural measures seem to be more effective than pharmacological means of attempting to attenuate jet-lag symptoms.

Travelling to compete in hot countries superimposes heat stress on the prevailing body clock adjustments. Prior acclimatisation to the heat is necessary in order to avoid deteriorations in performance. Additionally, a systematic rehydration strategy is necessary to offset effects of sweat losses.

These problems applied to rackets sports players (badminton, table tennis and tennis) competing at the 1996 Olympic Games in Atlanta. The acclimatisation strategy implemented by the British Olympic Association helped to prepare its representatives to offset travel stresses and their sequalae. These issues must be readdressed in preparation for major forthcoming tournaments, including the 1998 Commonwealth Games in Malaysia and the 2000 Olympics in Australia.

Tennis versus Golf: profile of demands and physical performance in senior players

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The purpose of the study was to compare the physiological profile of demands between tennis and golf and to investigate the long term effects of training and competition in tennis and golf on physical performance in senior players. Eighteen division IV and V male senior tennis players (59±2 yrs, 178±6 cm, 85±14 kg) and 21 male golfers (60±5 yrs, 179±5 cm, 82±7 kg) with a mean handicap of 20±7 participated in the study. We measured heart rate, lactate and oxygen consumption as well as serum concentrations of free fatty acids and glycerol and urine concentrations of adrenaline and noradrenaline during 18-holes of golf (4 h) and during a 2 h single competition in tennis. Aditionally all subjects underwent an incremental cycle ergometer test.

Mean playing experience was higher in tennis (20±7 yrs) than in golf players (10±4 yrs) whereas the mean playing time per week was higher in golf during summer (10±5 h vs 5±3 h) and winter (6±3 h vs 3±1 h). During the cycle ergometer test tennis players dispose of a significant better maximum performance (196±32 vs 169 ±41 watt), relative performance (2.32±0.53 vs 2.05±0.48 watt/kg) and anaerobic threshold (performance at 4 mmol/l blood lactate) than golfers (163±23 vs 139±33 watt).

Heart rate (137±15 vs 103±9 bpm), lactate (2.3±1.1 vs 1.5±0.2 mmol/l), $\dot{V}O_2$ (1.8±0.6 vs 0.9±0.3 l/min) and RPE (13.7±2.1 vs 11.5±1.5) were significantly higher during tennis match play than during a 4 h golf course. Post-exercise serum free fatty acids (1.51±0.57 vs 1.09±0.33 mmol/l) and serum glycerol (0.37±0.13 vs 0.21±0.06 mmol/l) as well as the urine concentrations of adrenaline (2.4±3.3 vs 1.2±0.7 µg/mg creatinine) and noradrenaline (11.5±6.0 vs 6.7±2.0 µg/mg creatinine) were also higher in tennis.

In conclusion, both sports allow a striking increase in caloric expenditure. Nevertheless, the metabolic and haemodynamic demands were uniformly higher in tennis than in golf. Only in tennis, the overall exercise intensity seems to be sufficiant to induce improvements in physical performance, as indicated by the results of the cycle ergometer test. However, golf can be suggested particularly for regeneration because of the low release of stress hormones.

Maximum oxygen uptake in junior and senior elite squash players.

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It is clear that there is a transition phase at elite level in squash, in which players from the junior under 19 age category move up to senior level. In addition to reflecting improvements in technical and tactical ability, this transition might also have accompanying changes in physiological characteristics such as maximum oxygen uptake ($\dot{V}O_2max$) which is commonly used as an indicator of aerobic performance potential. However, it is known that $\dot{V}O_2max$ is influenced by differences in the size of subjects and allometric modelling (Schmidt-Nielsen, 1984: *Scaling : Why is animal size so important?* Cambridge: Cambridge University Press) has been demonstrated as an appropriate technique to compare groups (Nevill et al., 1992, European Journal of Applied Physiology, **65** : 110-117). The purpose of this study was to use allometric modelling to explore possible changes in $\dot{V}O_2max$ in the transition from junior to senior play in elite level squash.

England national squad players provided written informed consent and were recruited to the study. The ages of the players (mean ± SE) were: Senior men (n=5) 24.9 ± 0.6, Senior women (n=7) 25.6 ± 1.7, U19 men (n=24) 17.7 ± 0.2 and U19 women (n=13) 16.7 ± 0.3 years. Maximum oxygen uptake was determined during an incremental test to volitional exhaustion on a motorised treadmill (Powerjog, Model MX2000). Expired air was collected and analysed via an on-line system (Covox Microlab, Exeter, UK), which was calibrated before and after testing using gases of known concentration and a syringe of known volume. Body mass was determined to the nearest 50 g using beam balance scales (Herbert and Sons). The $\dot{V}O_2max$ was expressed relative to body mass as a power function ratio using body mass raised to the power 0.67 (PFR67) ($ml \cdot kg^{-0.67} \cdot min^{-1}$), and as the natural log of this measure (lnPFR67). The suitability of an exponent of 0.67 was verified by log-log transformations of the raw data. A 2 × 2 (age × gender) MANOVA and univariate F tests were performed on the dependent variable ($\dot{V}O_2max$). Statistical significance was set at 0.05.

The PFR67 were : Senior men 274 ± 4, Senior women 215 ± 5, U19 men 252 ± 4 and U19 women 201 ± 4 (mean ± SE). For men and women, the PFR67 and lnPFR67 $\dot{V}O_2max$ data were greater in the senior than the U19 players ($P < 0.01$). In both age categories $\dot{V}O_2max$ was greater in men than the women ($P < 0.01$). The results demonstrate that $\dot{V}O_2max$ increases in both men and women from junior to senior level, and suggest that the use of intermediate training squads could ease the transition process.

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THE EFFICACY OF TRAINING ROUTINES AS A PREPARATION FOR COMPETITIVE SQUASH

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This study was concerned with measurement of physiological responses of county level squash players during commonly used training routines for squash. The warm-up period, boast and drive, boast drop and drive, and simulated game situations are commonly used as a preparation for competitive squash. While the routines also serve to groove skills and enable players to move towards autonomy of execution, they have a fitness requirement which has often been ignored or at least marginalised. This study monitored heart rate, blood lactate and oxygen consumption elicited from court sequences in players.

Each player (n = 12) wore a Cosmed K2 oxygen analyser and Polar Electro (PE3000) heart rate monitor throughout the sequence and blood samples were taken at the completion of warm-up and then following each of the training routines. A treadmill test was used to determine $\dot{V}O_2$ max and maximal heart rate to calculate the relative intensity of the Court routines.

Results show that training routines mimicked and superseded heart rate responses produced in competitive squash, previously described as 82.4%, 81.8% HRmax (Reilly & Halsall, 1995; Mercier et al, 1987). In particular, dynamic routines with excessive movements such as the boast, drop and drive elicited extremely high heart rate responses (90% of HRmax; 84% $\dot{V}O_2$ max). A simulated game, inclusive of rests between rallies, was found to be of similar intensity to boast and drive routines (>80% HRmax; 73% $\dot{V}O_2$ max), whereas warm up sequences were less intensive (<65% HRmax; 52% $\dot{V}O_2$ max). Despite these high heart rates blood lactate responses were relatively low (average mean 4.1 $mmol.l^{-1}$). This is perhaps indicative of the intermittent nature of squash with periods of intense effort followed by short rests.

While it is acknowledged the routines can be completed more or less intensively, the players in this study were encouraged to respond with maximum effort. In conclusion it seems that squash training routines, especially those with a dynamic nature, have excellent potential for county level squash players in developing sport specific fitness.

Aspects of Physiological Demands and Fitness for Squash

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Total Fitness for squash includes nine items, all of which have to be optimised to provide:- 1) the best racket techniques and court movement skills; 2) the best equipment; - rackets and balls, shoes and clothing; 3) the best on-court tactics at different stages of the game, match, and tournament; 4) an appropriate psychological approach; 5) excellent sports medicine, including physiotherapy and podiatry; 6)appropriate nutrition including fluid intake; 7) elite physiological and fitness preparation; 8) the best team selection; 9) top class team management

Regarding physical fitness itself, this also consists of a number of items; 1) Cardio-respiratory fitness ('aerobic fitness'); 2) Muscle endurance, - a combination of the ability to deliver appropriate anaerobic and aerobic power together with the equally important ability to recover. This is often termed 'local muscle endurance - or, somewhat inaccurately, 'anaerobic endurance'; 3) Muscle strength, more important in tennis than the other racket sports, but nevertheless, for squash players it is particularly important that they have a strong abdomen and lower back, reasonable leg strength, and that their grip strength is not below a threshold of about 40 - 45kg for men and 30-35 for women; 4) Muscle speed, an important component of power in all the racket sports, particularly off-the-mark speed of movement; 5) Flexibility, especially of quads and hamstrings, mainly to help prevent injury; 6) Low percentage body fat (7-12% for men, and 22-26% for women, at elite levels).

Squash is a game which may last from 6 minutes 48 seconds to 2 hours 48 minutes. One rally may last one stroke and 1.5 seconds, or 400 strokes and 10 minutes. More usually, - for training purposes, - rallies can be categorised into three main groups, those lasting less than 5 seconds, those between 6-20 seconds, and a small but important number which lasts upwards of 20, but not usually longer than 60 seconds. There are approximately 7 seconds between rallies, which are played at a stroke rate of up to 40 strokes per minute, i.e. 20 per player.

The heart rate rises in the first few minutes of play to 80-90% of maximum, which is maintained throughout the match. Body temperature may rise by 2°C in the first 40 minutes, thereafter more slowly. Male players lose may sweat at a rate of up to 2.0 litres/hour, and women at approximately half this rate. Systolic blood pressure rises by up to 30% in the first five minutes, but thereafter falls linearly to pre-match levels after 30-40 minutes. Diastolic blood pressure tends to fall by about 10mm Hg or more, according to standard, throughout the same period.

Oxygen consumption during the game ranges from 2.0 to 3.5 litres/minute (up to about 32ml/kg/min for women, 40ml/kg/min for men), with energy expenditures of 10 to 18 kcals (42 - 75kJ)/min. Lactic acid levels after 30-40 minutes play range from 3.5 to >10.0 mmol/l (for men, less for women) and may be reduced during play by exploitation of suitable tactics involving 'time shots' . Lactate levels may also be minimised by 4 to 8 weeks of suitably phased interval 'shadow-training' or 'ghosting'. Such interval-training regimes are suprisingly specific in their application to individual players. In players of all standards, a poorer tactical sense may surface as an apparent lack of physical fitness, e.g. if they let their opponent run them around too much.

Top class male players tend to have maximum oxygen uptakes in the mid-60's and upwards (ml/kg/min), high anaerobic thresholds (60 to >80% VO_2 max) and body fat percentages between 7 and 12%. On the Wingate anaerobic test they tend to have leg peak powers of 12.5-13.5W/kg, a 'fatigue index' of between -10 and -15 W/sec, and a 'recovery index' (on a repeat test 4 minutes later) of 95-98%. They tend to have hand-grip strengths of 45-60kg.

Female players tend to have a VO_2(max) in the low to mid-50's, with similarly high anaerobic thresholds, and body fat percentages in the 18 to 25% range. Their anaerobic leg peak powers tend to be around 7.5.-8.0 W/kg, and their 'fatigue indices' tend to be between -8 and -15W/sec, with 'recovery indices' of 94-100%, and grip strengths of 30-45kg. Within limits, the amount of force required to hold a racket tends to vary inversely with the diameter of the grip. So the anecdotal view of a thicker grip helping to alleviate 'tennis/squash elbow' does have some basis in fact, as the amount of force required to grip it is less.

On time-lapse cinephotographic analysis, players of county-standard and upwards tend to markedly deviate through the 'T' on moving from the front to the rear (or vice-versa) of the court; club and recreational players tend to have a more random movement pattern around the court. The Physics Department of Birmingham University has timed national standard men players hitting the ball at upwards of 70m/sec (>156mph), and club players at 40m/sec (90 mph). Due to the coefficient of restitution of the squash ball being set at around 20%, the front wall rebound speeds are of the order of 14 and 8m/sec, (31 and 18 mph) respectively. This disparity between hitting speed and rebound speed confuses beginners, who thus tend to over-run the ball.

Players of both sexes tend to have better-than-average simple and complex reflex response times, and to have good dynamic balance at upwards of 20sec out of 30sec at settings of 5 degrees from the horizontal on the stabilometer test.

A good pre-season physical training programme will incorporate the four strands of:-

1) aerobic/cardiorespiratory training. This involves a wide variety of modes of training, from aerobic interval on-court work (working for up to 10 repetitions of 2- 4 minutes, with 1 minutes rest) to 20 - 40-minute outdoor running or fartlek sessions, performed from two to four times weekly, depending on stage in the training macro-cycle.

2) lactate/glycolytic training (for anaerobic power, endurance and recovery). This involves 6 to 20 repetitions of on-court near-maximal 'ghosting' interval work of 30-45 seconds, with similar periods of an active (jogging) 'rest' ; usually one set, but possibly two, and work rest ratios may alter as the macro-cycle progresses.

3) phosphagen/speed training. This involves on-court interval regimes of possibly 10-14 repetitions of 10 seconds maximal speed activity, with 50 seconds (or more) active rest. Some of items 2) and 3) are often incorporated into various regimes of on-court pressure training.

4) A basic general strength training programme. As with most sports, the strength component is primarily needed to improve muscle power, product of force x velocity. For strength, the weights or loads should be of the order of 80+% single rep max, with steady movement, in sets of 4- 8; for speed, 50 - 65% single rep. max, in sets of 10 to 15, carried out dynamically. Free weight training exercises should include: cleans (posterior deltoid, triceps, gluteus medius quads, erector spinae, gastroc, soleus), back squats (quads, sartorius, iliopsoas, gluteus medius, hip adductors, erector spinae), split squats (hip adductors), biceps curls (brachialis, biceps), wrist curls (wrist flexors), wrist rolls (finger and wrist flexors), lateral raises (deltoids, suprspinatus), military presses behind neck (deltoid, supraspinatus, triceps), trunk curls (abdominals) together with (unloaded) back hyperextensions - and/or equivalents on fixed weight apparatus such as the multi-gym. Ideally, such work should include gradually introduced plyometrics, such as squat jumps, split jumps, and alternate leg bounds; together with medicine ball press throws, and twist tosses.

The physical programme should have an appropriate in-season maintenance component, and an appropriate series of phased meso and macro-cycles to peak for the highlighted tournaments. The programme will, of course, be fully complemented with solo and pairs practices, practice and conditioned games, and games against opponents selected to probe particular technical, tactical or physical weaknesses.

Squash players are not alone among racket players in too often wishing to train their strengths rather than their weaknesses, whether in skills or physical attributes, and whether on or off the court. So their weaknesses should be identitified (which is where field or laboratory fitness and strength tests help provide a diagnostic function). Once identified, relative weaknessesthey may be specifically trained. Here again fitness and strength testing helps monitor the training effects.

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AN INTRODUCTION TO THE BIOLOGY OF REFLEXRESPONSE AND A METHODOLOGY FOR DIFFERENTIATING BETWEEN REFLEX INTENSIVE AND PHYSICAL INTENSIVE SPORTS.

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Reflexes, which up to the present time have always been recognized as being extremely significant (but have remained a technical non-entity) in analyzing a sports competitors capabilities, successes and failures are explained and introduced in a technical manner into the sports science curriculum. The criteria for a measurement system which mimics the reflexresponse time of every individual racket sport (and several other sport) player during competition is described and defined. A methodology for subdividing all sports into one of two separate categories (Reflex Intensive, Physical Intensive) is demonstrated and introduced into the sports science classification index system. All racket sports are shown to fall into the reflex intensive sports category along with twelve other listed non-racket sports. All remaining sports are shown to fall into the physical intensive sports category.

The psychological skills of Britain's top young squash players

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Psychological skills training (PST) programmes have been increasingly included in the preparation schedules of performers at all levels (Greenspan & Feltz, 1989; Vealey, 1988; 1994; Weinberg & Comar, 1994). However, the reported use of such programmes in squash has been sparse suggesting a difference in the way elite squash players might prepare for competition. This preliminary study sought to determine the baseline psychological skills apparent in 13 young elite international performers, resident in Britain. These performers are likely to make a professional career from squash and their holistic development is of paramount importance to their future success. The Psychological Skills Inventory for Sports (PSIS R-5; Mahoney, 1989) was used as an evaluative tool to determine baseline cognitive skills and form part of a needs analysis to establish appropriate cognitive enhancement interventions. Performers were asked to assess the efficacy of their psychological skills by responding to each of the 45 self report items on their PSIS R-5 scale. These results support the notion of gender differences found in previous research (Mahoney, MacIntyre & Moran, 1996) but provide general support for typical scores established by Mahoney (1989) for elite performers in other sports. This study does show a significant difference in confidence $F_{1,12} = 6.68$, $P<0.05$ between males and females with males scoring significantly higher than females. When the results are compared with current rankings though, there appears to be strong congruence between good self reported scores on PSIS R-5 and higher national ranking. The study has confirmed previous findings (Mahoney & O'Leary, 1996) that suggest PSIS R-5 is robust enough and sufficiently sensitive to measure psychological skills in sport. This assessment can be incorporated into a needs analysis to provide appropriate support or interventions, though a more in depth appraisal, which acknowledges individual differences, should be conducted .

Using computerised notational analysis to create a template for elite squash and its subsequent use in designing hand notation systems for player development.

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Creating a database of a competitive sport and extracting from this database a tactical model of this particular game is one of the most desirable outcomes of notational analysis. Many coaches seek the template of tactical play at the highest level for preparation and training of both elite players, and also the developing players who aspire to reach the highest position. Particular databases, aimed at specific individuals or teams, can also be used to prepare potential opponents for match play. The aim of this work was to utilise computerised notation systems to create firstly a structural archetype of the game of squash at the elite level and then to extend this to a tactical model of the game. Hand notation systems were then developed for use by and for developing squads of players.

Nine matches of elite players (ranked in the world top 20) were videotaped at the finals of the 1996 British Open. All these matches were analysed using a comprehensive computerised notation system (Hughes and Knight, 1993, in **Science and Racket Sports**. London: E. & F.N. Spon, pp. 257-260) which was used post event from video. A summary of the template of the game is shown in Table.1.

Table 1. This model is based upon data taken from 5 matches involving players who were in the top 20 in the world at the time (1995-96 season).

Average number of shots/match	1089
Average number of shots/game	351.2
Average number of rallies/game	26
Mean rally length (19" tin)	13.52
Mean rally time	21s
Time between rallies	10s
Average number of winners/game - winning player	9 (8.9)
Average number of errors/game - winning player	5 (4.7)
Average number of winners/game - losing player	6 (6.2)
Average number of errors/game - losing player	6 (6.3)

The length of the rallies agrees with recent research, but differs from other earlier research - this is attributed to lighter rackets with increased power. In the tactical model a performance indicator, the ratio of winner to errors, W/E (Sanderson, F., 1983, Developing a hand notation system for squash. **Physical Education Review,** 6, No. 1, 19-23), showed significant differences ($P<0.01$) between the profiles of all the different categories of shots of winning players and losing players at elite level. The

highest ratios of W/E for both sub-sets of players was for the cross-court drive, the lowest ratio, of those shots that were played with significant frequency, were the boast and the straight drive. The shots that had the highest frequencies of errors were the straight drive and the straight drop. An analysis of responses to long and short shots by opponents produced a clear tactical hierarchy of shots from those particular parts of the court - the elite players resorting in the main to one of three or four tactical 'best options'. Further analyses, on serve and return, short shots and volleying created the patterns of responses that elite players use in their game at this level.

All these tactical models were used as a basis for creating nine systems for the notation of squash in-match in a simple, visual way, that require little or no data processing. The tactical ideas on which the systems are based are listed :-

- Service and return
- Positioning of shot - Straight-long or -short, cross-long or -short
- Winners and errors
- Winners and errors - and rally length
- Volleys
- Response to a short shot
- Response to a long shot
- Awareness of opponent when volleying
- Awareness of opponent when playing short.

There is a deliberate tactical progression within this list of systems and it has been found that this progression is useful when using the systems with squads of players that are of different standards. The systems are designed to be used by the players, for the players, and are all visual and therefore can provide immediate feedback. This use of the systems by the players has an extra benefit for the players, because it heightens their awareness of the importance of the tactical reason for the particular system. The ideas behind the systems and progressions of tactical development involved in the systems can easily be extended to other racket sports.

Using computerised systems as these to analyse performance, creating large amounts of accessible data, and to have the potential to analyse those data in a different number of ways, enables notational analysis to give to sport, and any other areas of performance, a new level of insight that has not yet been explored.