# CHAPTER 5

# CONCLUSIONS AND RECOMMENDATIONS

Specialization, which is the result of man's continual striving for improvement and development, has permeated almost every aspect of today's modern society (Ellwanger, 1973; Copley, 1975). According to Copley (1975) sport specialization generally involves work and scientific research in aspects such as equipment, training and conditioning, coaching, teaching and administration. Intensive literature surveys and numerous discussions with leading players and authorities have indicated that research in tennis compared to other sports has been grossly neglected with respect to training, conditioning, coaching and teaching of players (Copley, 1975; Fu & Stone, 1994). Efforts have only recently been made in order to understand the sport science of tennis. However, since 1990, great strides have been made in understanding the biomechanics, physiology, psychology, and sports medicine of tennis. This was done largely through research funded by the U.S. Tennis Association. Based on this information it is possible to develop programmes for better identification of injuries, preventative conditioning programmes and also for better skill acquisition programmes (Fu & Stone, 1994). At the competitive level, junior players are required to have sound stroke production and good physical fitness, combined with the psychological characteristics that enable both successful performance and normal socialization with children of their own age (Elloitt *et al*., 1989). The shoulder is of paramount importance to all competitive tennis players (Plancher *et al*., 1995). Turner & Dent (1996) found that 27% of all tennis injuries in junior players occur in the shoulder region. The shoulder girdle is prone to injuries because of its function to maximally accelerate and decelerate the arm while it maintains precise control over the racquet at ball contact (Hagerman & Lehman, 1988; Carson, 1989; Plancher *et al*., 1995). The complex interaction between muscle fatigue, eccentric overload and primary instability with secondary impingement can lead to disability in tennis players (Plancher *et al*. 1995). By exploring and understanding all the aspects of tennis dynamics, shoulder rehabilitation and conditioning programmes can be developed that will diminish disability and enhance performance in tennis players.

A total number of 42 tennis players, training at the Performance Centre and the International Tennis Federation at the University of Pretoria, were included in this experiment. Each player completed a questionnaire of his or her tennis and medical history. The players were then divided into a control group (22 subjects) and an experimental group (20 subjects). All the subjects followed specific exercise programmes; with the experimental group following an additional programme five times a week based on certain scientific exercise principles. This scientific programme focused on the prevention of shoulder injuries. Both groups completed a series of physical scientific tests as discussed under Procedures in Chapter 3.

To recapitulate, the purpose of this study was to determine whether following specific scientific exercises would prepare the tennis player for the stresses of the game and in this way reduce the occurrence of shoulder injuries throughout the year. The primary objectives of the study was to determine whether a specialized exercise programme, focusing on tennis dynamics, would minimize the occurrence of shoulder injuries in junior tennis players. The secondary objective was to determine the biomechanical working of the shoulder girdle in the various tennis strokes and the influence of specific exercises on the functioning of these muscles. In the light of the results discussed in Chapter 4, the conclusions and recommendations are presented accordingly:

Results of the tests done to determine **body composition** showed a significant difference ($p<0.05$) in the distribution of the **lean body** mass with the lean body mass at T1 being lower than the lean body mass at T3 in the *control group*. For the *experimental group* the **fat percentage** showed a significant decrease

($p<0.05$) from T1 to T3. The distribution of the **muscle percentage** at T1 was significantly different ($p<0.05$) from the distribution of the muscle percentage at T3 in the *experimental group* with the muscle percentage at T1 being lower than the muscle percentage at T3.

Results of the tests done to determine **muscle strength** and **endurance**, showed that there was a significant difference between the *control* and *experimental group* for **1RM bench press** ($p<0.05$) with the 1RM bench press measurements at T3 being lower for the *control group* than for the *experimental group*. Also, the 1RM bench press at T1 was lower than the 1RM bench press at T3 in the *experimental group*. The *experimental group* showed a significant increase from T1 to T3, peaking at T3 with the 1RM bench press. Statistically significant differences were also found at the 5% level of significance between the *control* and *experimental group* for maximum number of **push-ups** in 1 minute. The *control group* had a lower maximum number of push-ups in 1 minute at both T2 and T3 than the *experimental group*, and the maximum push-ups in 1 minute at T1 were lower than the maximum push-ups in 1 minute at T3 in the *experimental group.* The *experimental group* showed a significant increase from T1 to T3 in the maximum number of push-ups in 1 minute. Statistically significant differences were found at the 5% level of significance between the *control* and *experimental group* for **grip strength** in both the dominant and non-dominant hand. The grip strength of the dominant hand as well as the non-dominant hand at T1 was lower than the grip strength of the dominant hand and the non-dominant hand respectively at T3 in the *experimental group*. The grip strength of the dominant hand at T1 was lower than the grip strength of the dominant hand at T3 in the *control group.* The grip strength of the non-dominant hand at T1 was lower than the grip strength of the non-dominant hand at T3 in the *control group;*

Results of the tests done to determine **isokinetic muscle strength** showed that a statistically significant correlation ($p<0.05$) was found with regard to the strength of the **internal rotators** of the non-dominant shoulder at T3, with the *experimental group* having a higher measurement than the *control group*. The **internal rotators** and **external rotators** of both the dominant and non-dominant shoulders were lower at T1 than at T3 in the *experimental group* ($p<0.05$). The **external rotators** of the non-dominant shoulder at T1 were lower than the external rotators of the non-dominant shoulder at T3 in the *control group*. The strength of the **flexor muscles** for the non-dominant shoulder at T1 was lower ($p<0.05$) than the strength of the flexor muscles for non-dominant shoulder at T3 in the *experimental group*. The strength of the **elbow extensors** for the dominant as well as the non-dominant elbows was lower at T1 than at T3 in the *experimental group.*

Results of the tests done to determine **flexibility** showed a statistically significant difference with the **internal rotators** and **external rotators** of the dominant and the non-dominant shoulders being lower at T1 than at T3 in the *experimental group*. Also, the external rotators of the non-dominant shoulder of the control group were lower at T1 than at T3.

Results of the tests done to determine **posture** showed that for the control group, 54.5% of players had **scoliosis** at T1 and 40.9% at T3, and for the *experimental group* 55% of the players had scoliosis at T1 compared to the 30% at T3. Although the percentage of players with scoliosis in both the *control* and *experimental groups* showed a decrease from T1 to T3, the players in the *experimental group* showed a larger decrease than those in the control group. In the *experimental group* 38.5% of cases had a **CM bend** that was less than 5cm in T1 and became more than 5cm in T3. In the *control group* 20% had a CM bend less than 5cm in T1, which became greater than 5cm in T3. For the *control group* 63.6% of the players' shoulder heights were not level at T1, compared to the 40.9% at T3. For the *experimental group* 55% of the players' **shoulder heights** were not level at T1, compared to 30% at T3. 63.6% of players in the *control group's* non-dominant shoulders were higher than the dominant shoulder at T1, compared to the 40.9% of players at T3. For the players in the *experimental group*, 50% had a higher non-dominant shoulder and 5% a higher dominant shoulder at T1, compared to 25% and 5% respectively in the *control group*, at T3. In the *control group* at T1, 63.6% of the group's **hips** were not level, compared to 40.9% at T3. For the experimental group at T1, 55% of the group's hips were not level, compared to 30% at T3. The percentage of players with **kyphosis** in both the *control* and *experimental groups* decreased from T1 to T3. In the *control group*, the percentage of players with kyphosis decreased from 63.6% at T1 to 46% at T3 and the *experimental group* decreased from 55% at T1 to 30% at T3. The percentage of players with **lordosis** in both the *control* and *experimental groups* decreased from T1 to T3. In the *control group*, the percentage of players with lordosis decreased from 50.0% at T1 to 40.7% at T3, compared to the *experimental group* that decreased from 30% at T1 to 25% at T3. Results of the tests done to determine the occurrence of injuries showed that the players with **no injuries** in the *control group* stayed stable from T1 (54.5%) to T2 (54.6%) where after it increased to 59.1% at T3. In the *experimental group* the total players with **no injuries** stayed stable from T1 (55.0%) to T2 (55.0%) where after it increased to 85% at T3. In the *control group* the percentage of players with **grade 1 and 2** injuries were 13.6% at T1, it increased to 18.2% at T2, and decreased to 13.6% at T3. In the experimental group 15% of the players had **grade 1** injuries at T1. This percentage increased to 30% at T2 where after it decreased to 15% at T3 again. The percentage of players with **grade 2** injuries remained stable at 10.0% from T1 to T2 in the *experimental group*. None of the players had **grade 2** injuries at T3. In the *control group* 9% of players had **grade 3** injuries at T1, with none having it at T2 and T3. In the *experimental group* the percentage of players with **grade 3** injuries remained stable at 5.0% from T1 to T2. None of the players had **grade 3** injuries at T3. In the *control group* 4.5% of players had **grade 4** injuries at T1. This stayed more or less stable at T2 (4.6%) and increased to 9.1% at T3. In the *experimental group* 10.0% of players had **grade 4** injuries at T1. None of the players had **grade 4** injuries at either T2 or T3. In the *control group* 4.5% of players had **grade 5** injuries at T1, none had it at T2, and 4.5% had it at T3. In the *experimental group* none of the players had

**grade 5** injuries at T1, T2 or T3. In the control group none of the players had **grade 6** injuries at T1 or T3. At T2, however, 4.6% of players had **grade 6** injuries. In the *experimental group* 5.0% of players had a **grade 6** injury at T1 and none of the players had this type of injury at T2 or T3.

Due to the results of the parameters obtained from the physiological tests, the hypotheses of this study can thus be accepted. It is important to notice that the two important aspects in preventing overuse injuries in tennis, showed a positive improvement. The strength of the rotator cuff muscles, which are the primary muscles preventing the humerus head from slipping out of the glenoid cavity during play and which is active during all tennis strokes, improved significantly from T1 to T3 in the *experimental group* (Priest & Nagel, 1976; Reece *et al*., 1986; Roetert & Ellenbecker, 1998; Rubin & Kibler, 2002). Also, the programme succeeded in strengthening the opposing muscle groups in both strength and flexibility, minimizing muscle imbalances in the body (Burnham *et al*., 1993; Roy *et al*., 1995; Kirshblum *et al*., 1997; Roetert & Ellenbecker, 1998; Salisbury *et al*., 2003).

The hypotheses of this study have been successfully completed according to the results obtained during the tests and the supporting literature. There are, however, certain aspects in the physiology in tennis, as well as the differences related to sex and ethnical groups that need further research (Salisbury *et al*., 2003). The following recommendations are thus to expand on the improvements and the scientific knowledge of tennis:

- ➔ a larger group of subjects must be used in order to determine the differences between male and female players;
- ➔ two different groups can be used in order to determine ethnical differences;
- ➔ more research needs to be done on the different stroke techniques that the players use; and