A Multidisciplinary Investigation into Markers of Physical Fitness of Elite Young Soccer Players

This dissertation is submitted in accordance with the requirements of Liverpool University for the degree of Doctor of Philosophy.

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By James Joseph Ryder

This work is original and has not been submitted previously in support of a degree, qualification or other course.

Signature............................... Date...................

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Abstract

The aim of this thesis was to utilise a multidisciplinary approach to investigate the effect participation in competitive soccer has on the physical fitness, mood state profile, and immune function of elite young soccer players aged between 11 and 16 years. The investigation encompasses two seasons: the first (S1) a season where no restriction on the number of games players could participate in and the second (S2) a season where players were restricted to only 36 games across the season. Data from the physiological study indicates that the physical stimulus of competitive soccer across an unrestricted season is sufficient to maintain aerobic fitness, and improve both 10 metre sprint and agility run performance. Limiting to 36 competitive games young players are allowed to participate in results in a reduction in aerobic capacity and no improvement in either 10 metre sprint or agility run performance.

Results of the psychological study indicate that total mood disturbance (TMD) increased in all age groups across an unrestricted season as a result of the physiological stress experienced in soccer matches. There was no significant change in TMD across the restricted season suggesting a reduction in the physical stress experienced by the young players across a restricted season. The results of the modified Daily Analysis of Life Demands in Athletes demonstrate there was no significant change in the "external stressors" experienced by the subjects that may have affected the TMD. This appears to support the findings of the physiology study where the physical stimulus was sufficient to maintain aerobic fitness and increase 10 metre sprint and agility run performance across S1 but restricting the number of games resulted in a decrease in aerobic capacity across S2.

Results of the immunology study indicated large inter- and intra-subject variability in both the salivary IgA/osmolality ratio and the

salivary cortisol/osmolality ratio indicating its unsuitability as a marker of stress in a field setting.

The results of this study show that restricting, to 36, the number of games young children are allowed to participate in during a full season reduces the physical stimulus the players experience. This can result in a reduction in their aerobic capacity as well as specific changes to both the anaerobic fitness component and the psychological component related to training and playing. It is important, that in order to maintain the fitness profile, both physiological and psychological, that coaches ensure that players in their care have a sufficient physical stimulus that represents the game of football. In order to ensure overtraining does not occur, this stimulus should not be football per se but should be closely related to it but should also have important elements of cross training.

List of Abbreviations

LRC:	Linear Regression Coefficient
POMS:	Profile of Mood States
POMS-A:	Profile of Mood States for Adolescents
BRUMS:	Brunel Mood Scale (formerly called POMS-A)
TMD:	Total Mood Disturbance
DALDA:	Daily Analysis of Life Demands for Athletes
OTS:	Overtraining syndrome
ELISA:	Enzyme Linked Immunoassay

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1. Introduction

There has been little research investigating the effects of the long term participation of children in soccer on their levels of physical fitness and no literature specifically investigating the effect of restricting the number of games young players are allowed to participate in. This thesis examined the effect of participation in competitive soccer on the physical fitness of soccer players, aged between 11 and 16 years old, across a complete season. During this season the players were allowed to participate in an unrestricted number of games. The results from the unrestricted season were then compared to those of equivalent aged subjects monitored across a season where the players were only permitted to play in 36 games.

The study used field tests, selected to represent the physiological demands of competitive soccer, to monitor the subjects' levels of fitness. Psychological markers of mood states and qualitative measures of the sources and symptoms of stress were used in conjunction with markers of immune function in order to identify the level and sources of both physical and psychological stress placed on the players to across each season.

The thesis is presented with a review of the current literature (Chapters 2-5) in which each discipline (physiology, psychology and immunology) is discussed separately. The general methods (Chapter 6) describes the experimental methods used within each of the three studies conducted. The application of the tests and results are presented in Chapters 7 to 9, with three case studies used to illustrate the benefit of a multidisciplinary approach to monitoring the fitness of young soccer players. Finally, Chapter 11 provides a general discussion to integrate the results of the three disciplines investigated.

2. Physiology: Review of Literature

Section 2.1 of the review of literature identified the physiological demands of soccer and the key fitness parameters and movement patterns commonly utilized during competitive match play. The effect of training and growth/maturation on each of the selected parameters was reviewed.

2.1 Physiological Demands of Soccer

2.1.1 Physiological Studies: Adult soccer players

The majority of the studies investigating the physiological load of soccer players have been carried out with adult players as subjects and using time-motion analysis to examine the distances moved by players during the game (Reilly and Thomas, 1976., Mayhew and Wenger, 1985., Bangsbo, *et al.*, 1991., Ali and Farrally, 1991). A few studies have used heart rate monitoring as an alternative method to measure physiological demand (Rhode and Espersen, 1984, Ali and Farrally, 1991, Caprinica *et al.,* 2001.).

2.1.2 Physiological Load of Soccer: Time-Motion analysis

In order to estimate the physiological demands placed on soccer players, it is useful to identify the intensity and duration of the exercise. An indication of total workload can be estimated from the overall distance covered during a game (Bangsbo, 1993; Ewing and Maile, 1993; Tumilty, 1993; Reilly, 1994; 1996). This can be further broken down into the discrete actions of individual players for a whole game, such as sprinting, jogging, tackling and heading. These actions or activities can then be classified according to type, intensity, duration and frequency (Reilly, 1994).

Whilst the values obtained in such studies vary, there is a general consensus that outfield players travel approximately 10 km per 90 min game, making it a predominantly an aerobic activity (Mayhew and Wenger, 1985; Ewing and Maile, 1993; Reilly, 1994). The data presented in Table 2.1 gives examples of the different values obtained in these studies.

Table 2.1: Examples of the average distances travelled by outfield players during professional soccer matches

Source	Distance Covered (metres)
Reilly and Thomas (1976)	8680
Van Gool (1984)	10245
Withers *et al.*, (1988)	11527
Bangsbo (1999)	10800
Reinzi *et al.*, (2000)	8638 (South American players)
Reinzi *et al.*, (2000)	10104 (English players)
Strudwick and Reilly (2001)	11264

The values given for distance covered demonstrate some variation, partly because of the different technologies used in the studies (Reilly, 1994), but other reasons include: country where the data was collected, different tactics; weather conditions; strength of the opposition; technical strength of the players; and importance of the match (Bangsbo, 1993; Ewing and Maile, 1993; Tumilty, 1993; Reilly, 1994). Styles of play have also been demonstrated to have a notable effect on the work rates of the players (Bangsbo *et al.*, 1991; Ewing and Maile, 1993; Tumilty, 1993). A short passing game, where the emphasis is on retaining possession and making incisive quick bursts only at key moments, is said to place a significantly lower physical demand on the player than a direct style. The more direct style involves the ball being played forward at pace and can result in play switching ends quickly with players having to cover more ground (Bangsbo *et al.*, 1991; Tumilty, 1993; Reilly, 1994).

Further information on the physical demands of soccer can be obtained by analysing the movement patterns players perform during a match. These movements include: standing still; walking; jogging; sidestepping; striding (or cruising); and sprinting (Reilly and Thomas, 1976; Van Gool *et al.*, 1984; Bangsbo *et al.*, 1991; Tumilty, 1993; Reilly, 1994). Almost 1000 different movements are undertaken per game (Reilly, 1994). However, it must be noted that one limitation with using notational analysis to estimate the physiological load of soccer, is that the intensity level is mostly based on the subjective opinion of the observers (Van Gool *et al.*, 1984).

The research investigating the movement patterns adopted during competitive match soccer is shown in Table 2.2. It demonstrates that adult soccer players perform the vast majority of their exercise at a low intensity (Tumilty, 1993) and run with effort (cruise or striding) every 10 seconds. Players only engage in an all out sprint once every 90 seconds (Bangsbo *et al.*, 1991; Reilly, 1994).

Table 2.2: Time spent in each movement mode as a % of total match time

Reference:	Position	Stand/walk	Side/back	Jog	Stride	Sprint
Van Gool *et al.*, (1984)		42.9		42.6		7.5
Mayhew and Wenger (1985)	Midfield	48.7	2	38	11.3	
Bangsbo *et al.*, (1991)	Defence	64	1	33		
	Midfield	51	1	43	2.1	0.7
	Forward	63	1	34		
Strudwick and Reilly (2001)		36	10	41	10	3

More recently O'Donoghue (2003) investigated the number and duration of high intensity bursts of exercise performed during English Premier League Soccer. This showed that these elite players perform bursts of high-intensity activity of a range of durations with most bursts lasting four seconds or less (O'Donoghue, 2003). More detailed analysis of this data demonstrates that on average, the players perform 13.4 sprints of zero to two seconds every 15 minutes. This suggests that soccer players regularly cover a distance much less than 10 metres per sprint.

2.1.3 Physiological Load of Soccer: Heart rate monitoring

Capranica *et al.,* (2001) recommend heart rate (HR) monitoring as the most applicable indirect method of assessing work load during soccer matches, as the physical nature of the game renders gas analysis with either Douglas bags or portable gas analysis systems impractical (Rhode and Espersen, 1984; Ali and Farrally, 1991).

There have only been a small number of studies investigating the heart rate profiles of 11-a-side soccer matches. The studies that have used heart rate to investigate the physical workload during these games have included practice matches, simulated games and training matches (Reilly, 1994). Tables 2.3 and 2.4 show details of a study investigating the heart rate attained during competitive soccer.

Table 2.3: Mean heart rate (± sd) for semi-professional, university and recreational adult players for an entire game. (Ali and Farrally 1991).

	Semi-professional	University	Recreational
Forward	173 (12)	171 (13)	173 (13)
Midfielder	176 (9)	173 (10)	170 (12)
Defender	166 (15)	156 (13)	162 (13)

Table 2.4: mean heart rate (± sd) for semi-professional, university and recreational adult players during the first and second halves of a game. Taken from Ali and Farrally 1991.

	Semi-pro		University		Recreational	
	1st half	2nd half	1st half	2nd half	1st half	2nd half
Forward	174 (13)	172 (12)	172 (13)	170 (12)	174 (13)	172 (13)
Midfielder	178 (9)	174 (9)	175 (10)	171 (10)	172 (13)	169 (12)
Defender	170 (15)	162 (12)	160 (14)	152 (11)	163 (14)	159 (13)

These results indicate that there was no discernible difference between the heart rates of the forward players of all three levels of football, with the average heart rates being approximately 172 bpm. Defenders have been shown to be placed under the least physiological strain in university and recreational players with average heart rates of 158 bpm compared with 172 bpm in the forward players.

The mean heart rate obtained throughout the full 90 minutes, for all three standards of player, was approximately 170 bpm (although no detailed analysis of the heart rate profiles was included) indicating that the game is played at a high intensity, even at a recreational level (Ali and Farrally, 1991).

2.1.4 Physiological Studies: Young soccer players

There is little research investigating the physiological demands of a soccer match in youth team or young soccer players. Caprinica *et al.,*

(2001) investigated the heart rate responses of six pre-pubescent soccer players during an 11-a-side soccer match, played on a regular sized pitch[1]. During this investigation heart rate was monitored every five seconds and the time spent in each mode of movement noted. Walking accounted for 38%, running 55%, inactivity 4%, jumping 3% and ball contact time was less than 1%. The investigators also differentiated between the duration of each period of running. Continuous running for less than 10 secs and less than 20 secs accounted for 64% and 21% of all running activity respectively (Capranica *et al.*, 2001). It would appear that young players are running for a larger proportion of a soccer match than adult players, however there is no distinction made between different running intensities such as; jogging, sprinting or cruising. Thus a more detailed analysis of the movement patterns of young soccer players is not possible.

The data in Fig 2.1 shows the heart rate profile of young soccer players during a competitive 11-a-side game (Capranica *et al.*, 2001). Analysis of the values obtained shows that the majority of the work performed by young soccer players (aged 11 years old) is at a high intensity. Mean heart rates exceeded 170 bpm for 88% of the first half and 81% of the second half. The heart rates exceeded 85% of the approximate maximal heart rate of 200bpm (Armstrong, 1997), with values being obtained in excess of 210 bpm. This is slightly higher than the values obtained for adults (170 bpm Ali and Farrally 1991), although this could be as a result of the sub-maximal heart of children being up to 30 bpm greater than in 18-year olds performing the same task (Bar-Or, 1983). However, the same study also indicated that young children spend a larger proportion of match play running than adult soccer players (Capranica *et al.*, 2001). Consequently it is apparent that during a competitive soccer match young players are exercising for a prolonged period of time at an

[1] Regular-sized soccer pitch measures 100 x 65m

intensity level high enough to potentially elicit an improvement in aerobic fitness (ACSM, 1990).

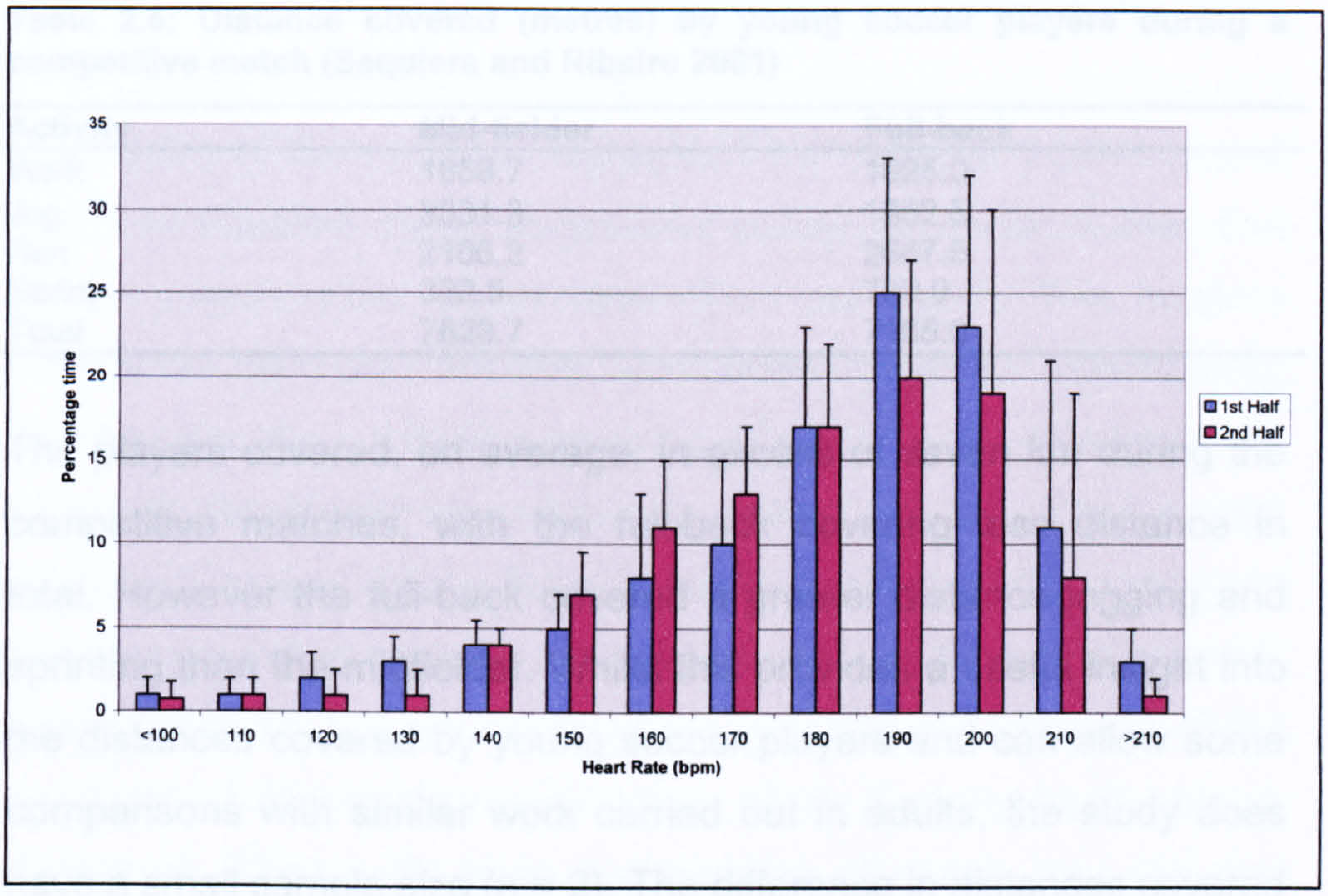

Fig 2.1: Heart rate distribution during competitive soccer, in young soccer players (Capranica *et al.*, 2001)

Drust and Reilly (1997) also investigated heart rate during youth team soccer during 8-a-side games in 18 children including both males and female participants (mean age 10 ± 1.6 years). No significant differences were found between either positions or sexes so data were presented together. The mean heart rate was 169 beats/min during the 10 minute game, which would appear to be slightly lower than those recorded by Caprinica *et al.*, (2001). However the difference between the studies may be accounted for by a reduction in pitch size during this study and the relatively short duration of the matches (Drust and Reilly, 1997).

Only one has investigated the distance covered by young soccer players (Seqeira and Ribeiro, 2001). Sequeira and Ribeiro (2001) carried out a case study with two 16-year-old international players, aiming to quantify the distances covered performing the different activities of walking, jogging, running, and sprinting during competitive matches (Table 2.5).

Table 2.5: Distance covered (metres) by young soccer players during a competitive match (Sequiera and Ribeiro 2001)

Activity	Mid-fielder	Full-back
Walk	1858.7	1925.0
Jog	3331.3	1862.5
Run	2106.2	2647.5
Sprint	332.5	730.0
Total	7628.7	7165.0

The players covered, on average, in excess of seven km during the competitive matches, with the full-back covering less distance in total. However the full-back covered a greater distance jogging and sprinting than the midfielder. Whilst this provides a useful insight into the distances covered by young soccer players and can allow some comparisons with similar work carried out in adults, the study does have a small sample size (n = 2). The difference in distances covered may be due to, differing levels of fitness between the subjects as well as the previously listed methodological problems.

Further research is required to identify the movement patterns and activities performed by young soccer players. However, the limited work available would suggest that aerobic fitness, speed over a short distance and a level of agility are important physical attributes for a young elite soccer player.

The work investigating movement patterns in adult soccer players differs from that in children. Capranica *et al.,* (2001) demonstrated that young players spend 55% of match time running with 21% of the time involving continuous running for up to 20 seconds. This suggests that children spend a greater proportion of match play running, than adults, and spontaneously maintain the nature of their activity (Capranica *et al.,* 2001). No positional differences were observed in the work rate profiles of young soccer players indicating that role specialisation is not important in young players (Capranica *et al.*, 2001).

2.1.5 Energy Systems in Soccer

This review of literature has highlighted the movement patterns and distances travelled during competitive soccer. It has highlighted that soccer players cover on average 10km per match. This involves periods of sprinting, running with effort, jogging, sidestepping, walking, standing still and jumping (Reilly, 1994). Consequently soccer is considered an activity demanding of each of the energy systems (Casajus, 2001). The 90 minute duration of the match and the average distance covered (10km) suggests a large contribution of energy from the aerobic system (Casajus, 2001). Estimation of the heart rate of soccer players indicates, adults showing heart rates in excess of 170bpm for large a proportion of match play (Ali and Farrally, 1991). This is equivalent to between 70 and 80% of their predicted maximum heart rate (Londeree and Moeschberger, 1982). Young soccer players have demonstrated heart rates in excess of 170bpm for 88% of the first half and 81% of a soccer match, with values in excess of 200bpm being recorded. These heart rate data confirms the contribution of the aerobic system during soccer match play. However, soccer also consists of bursts of maximal effort (Rienzi *et al.*, 2000) which can last up to four seconds in duration (O'Donoghue, 2003). This suggests that anaerobic power also plays an important role in the energy provision for soccer match play (Casajus, 2001).

2.2 Aerobic Fitness in Children

As outlined previously, soccer participation involves a large provision of energy from the aerobic energy system (Casajus, 2001). Consequently the literature investigating effect of both training and growth/maturation on aerobic capacity of children was reviewed.

2.2.1 Endurance Training in Children

The effect of aerobic training in adult populations is well documented. Improvements in maximal aerobic capacity (VO_2 max) are possible if; the subject performs "continuous activity of large muscle groups, three to five sessions per week for 20 – 60 minutes, at an intensity eliciting a heart rate of 60-90% of maximum" (ACSM, 1978; 1990). However, the efficacy of such training in children remains an area of some debate (Rowland, 1985; Malina, 1995; Rowland and Boyajian, 1995).

There have been a number of studies investigating the effect of training on aerobic fitness in children (Bar-Or and Zwiren, 1973; Stewart and Gutin, 1976; Gatch and Byrd, 1979; Rowland, 1985; 1992; Payne and Morrow, 1993; Rowland and Boyajian, 1995; Pate and Ward, 1996; Rowland, 1997). However, results have not consistently shown aerobic training to result in an increased aerobic capacity (Pate and Ward, 1996). Consequently a number of authors have questioned whether such training can be expected to elicit a training response in children (Rowland, 1985; 1992; Rowland and Boyajian, 1995). However, the inconsistency in findings could be as a result of simple methodological inconsistencies e.g. training intensities and durations that failed to satisfy the ACSM (1990) guidelines for improving aerobic fitness (Payne and Morrow, 1993; Rowland and Boyajian, 1995; Pate and Ward, 1996; Rowland, 1997).

Another proposed reason for aerobic training failing to result in an increase in aerobic capacity in children could be due to relatively high initial VO_2 max. levels, consequently further increases would not be expected (Hamilton and Andrew, 1976; Stewart and Gutin, 1976; Mirwald *et al.*, 1981; Krahenbuhl *et al.*, 1985; Rowland, 1985; Vaccaro and Mahon, 1987; Payne and Morrow, 1993; Rowland and Boyajian, 1995; Tolfrey *et al.*, 1998). Rowland (1992) supports this by suggesting the magnitude of observed increases in fitness is inversely proportional to the initial aerobic fitness levels.

Tolfrey *et al.,* (1998) conducted a matched pairs study (with both boys and girls) involving a 12-week stationary cycling programme. Subjects exercised at 80% of their peak heart rate for 30 minutes, three times a week. They concluded that exercise training alone did not significantly improve peak VO_2. Whilst this study did not result in an increase in aerobic fitness it was suggested that a more intensive exercise stimulus may increase children's aerobic capacity (Tolfrey *et al.*, 1998).

Baquet *et al.,* (2001) used a 20-metre shuttle run and seven minute run (D7) to investigate the effect of a 10-week high-intensity training programme (exercising at 90-120% of the maximal aerobic speed[2] [MAS]) on aerobic fitness. Aerobic performance, on the shuttle run, increased by 3.8%. The distance covered during the D7 test was 7.5% greater post training and the average running speed during the test represented 95% (pre-test) and 99% (post-test) of MAS. This indicates a significant increase in the duration of maximal running velocity (Baquet *et al.*, 2001). Whilst these data suggest that high intensity exercise training results in an increase in aerobic capacity it did not include any values for maximal oxygen uptake. However, when interpreting the results of Tolfrey *et al.,* (1998) and Baquet *et al.,* (2001) it is important to notice that both utilize tests that involve self-regulation of pace. This may lead to an increase in performance due to habituation.

[2] Maximal aerobic speed (MAS) is defined as the lowest speed requiring the maximal oxygen consumption (Baquet *et al* 2001)

Mosher *et al.*, (1985) used a mile run to investigated the effect of a 12-week interval-training programme on pre-pubertal, elite level male soccer players. Subjects then undertook three 15-20 minute training sessions, with an age-matched control group participating only in soccer. The experimental group were asked to perform a range of sport specific high intensity drills with a work:rest ratio between 1:2 and 1:3. The experimental group showed a significant decrease in the time taken to complete the 1-mile run, whilst the control group demonstrated a significant increase. These findings indicate that high-intensity interval training can improve a six to eight minute endurance performance which has a high aerobic component (Mosher *et al.*, 1985) although this improvement may have been as a result of habituation.

LeMura *et al.*, (1999) used strict inclusion criteria to carry out a meta-analysis of the work investigating the efficacy of aerobic training in children. The data showed that VO_2 max increased significantly by 6%, with the pre-training value of 47.2 $ml.kg^{-1}$ (sd 4.3) increasing to 50.1 $ml.kg^{-1}$ (sd 4.6) post-training. Further analysis showed that the older children (11-13 years) improved significantly more than the younger children (8-10 years) (LeMura *et al.*, 1999), which appears to support the theory that training has a lesser effect in the first decade of life (Kobayashi *et al.*, 1978; Gatch and Byrd, 1979). However there was not a consistent effort made to control for sexual maturation in this study. Payne and Morrow (1993) provide supporting evidence for this. Their meta-analysis showed a 5% increase in aerobic capacity, with the mean pre- and post-test VO_2 max values were calculated at 44.66 and 48.39 $ml.kg^{-1}.min^{-1}$ (Payne and Morrow, 1993).

In summary, the efficacy of aerobic training in children remains contentious (Rowland and Boyajian, 1995). However, there is a growing body of evidence to suggest that, if the training intensity is of a sufficient intensity, the aerobic capacity of children can be improved (Baquet *et al.*, 2001).

2.2.2 The Effect of Soccer Participation on Aerobic Fitness

There is a distinct paucity of literature pertaining to the effects of soccer participation on the physical fitness of children. Examination of the findings of the control group in a study by Mosher *et al.*, (1985) allows the investigation into the effect of 12-weeks soccer participation on the fitness of young participants. The data demonstrate a slight decrease in aerobic capacity, a decrease in performance on the anaerobic speed test, and no significant change for the 40-yard (36.40 metres) run. This suggests that participation in soccer, with no specific fitness training, does not result in increases in fitness over a 12-week period, and may result in a slight decrease in fitness. However, it must be noted that no details were given as to the number of games the subjects participated in, or to the nature of these games (adult or child sized pitches or duration). It should also be noted that this study only made observations over 12 weeks and not a full season.

Berg *et al.*, (1985) investigated the effect of participation in competitive soccer on physical fitness in children. Young soccer players (n = 20 mean age 11.8 yrs $\pm$ 0.3 years) participated in twice weekly, 75 minute training sessions and one 60 minute game (two 30-minute halves). The control group (n = 9 mean age 11.5 $\pm$ 0.6 years) were classified as normally active but participated in no organised sport at the time. The only significant change in the measured parameters was a reduction in oxygen consumption at the sub maximal running speed of 134 $m.min^{-1}$. There was no concomitant decrease in sub maximal heart rate, consequently the observed change was attributed to an improvement in running efficiency rather than an improvement in cardio-respiratory fitness (Berg *et al.*, 1985). As such it was concluded that participation in competitive soccer over 12 weeks did not result in an increase in aerobic capacity.

No study has observed the change in fitness, of elite young soccer players, over a full season. Berg *et al.,* (1985) used games of only 60 minutes in duration, rather than the 90 minutes used during competitive soccer. As such the question of how fitness alters over a complete season (in children) remains unanswered.

2.2.3 Aerobic Capacity and Growth/Maturation

There are a number of methodological problems commonly associated with the estimation of aerobic capacity in children (LeMura *et al.*, 1999). These may be partly responsible for the conflicting results between studies examining changes in children's' aerobic capacity. These include: short attention spans, poor motivation, and lack of sufficient understanding of experimental protocols, therefore making it harder to elicit maximal effort (Armstrong and Welsman, 2000). Despite this it is widely agreed that aerobic capacity increases with physical maturation and age (Armstrong and Welsman, 2000).

Armstrong and Welsman (1994) showed an almost linear relationship between age and aerobic capacity; with the magnitude of this increase in VO_2 max reported to be between 1.22 to 3.06 litre min^{-1} in boys aged between the ages of 8 and 16 years. Armstrong and Welsman's review of published longitudinal data and some of their unpublished data (reported in Armstrong and Welsman 2000) demonstrated a consistent picture of a gradual rise in peak VO_2 in boys, from 8 through to 16 years. Mirwald and Bailey (1981) quantified the annual increase in peak VO_2 as 11% in boys, with the greatest increase occurring between 13 and 14 years (0.31 litre min^{-1}) and 14 and 15 years (0.32 litre min^{-1}).

As well as observing the relationship between aerobic capacity and age some authors, Armstrong *et al.,* (1991) and Davies *et al.,* (1972), have investigated the changes in aerobic capacity and body mass or stature. Generally peak oxygen consumption is strongly correlated with body mass or stature demonstrating correlation coefficients (r values) typically exceeding 0.70 (Armstrong *et al.*, 1991).

2.3 Anaerobic Capacity

As previously outlined soccer involves repeated bursts of all-out sprinting once every 90 seconds (Reilly and Thomas, 1976; Van Gool *et al.*, 1984; Bangsbo *et al.*, 1991; Tumilty, 1993; Reilly, 1994; Reilly *et al.*, 2000). The majority of sprints performed during soccer are less than four seconds in duration with approximately half these being less than two seconds (O'Donoghue, 2003). Reilly *et al.,* (2000; FA, 2003) suggest that these short sprints are important when players are attempting to win the ball, evade a tackle, or dribble past opposition players; all of which are key actions that need to be performed during a match. Kollath and Quade (1993) investigated the difference in sprint performance between amateur and professional players, using 5, 10, 20 and 30 metre sprint performance. They highlighted that the amateur players were about half way behind the professionals by the first 10 m of the overall distance (Kollath and Quade, 1993). They suggest that particular attention should be paid to the sprint performance over 10 metres. This would appear to be supported by the findings of O'Donoghue (2003) who showed that the majority of sprints during an English Premier League match were less than four seconds in duration. Bangsbo (1994) agreed with this hypothesis suggesting that the ability to "power away" from opposition players is a key skill for attacking players, thus suggesting that speed and acceleration are vital for the modern day soccer player.

2.3.1 Growth and Maturation of Strength and Power

Leg strength has been shown to play an important role in short sprints (Dececluse *et al.*, 1995; Young *et al.*, 1995; Bret *et al.*, 2002). Studies on the effect of growth and maturation on strength suggest that, in boys, muscular strength increases fairly linearly with chronological age until approximately 13-14 years of age (mid-puberty). It is then followed by a significant increase in the rate of strength development through the late teen period (the pubertal years), followed by a slower increase into the early or mid-twenties (Beunen *et al.*, 1988; Blimkie, 1989; Parker *et al.*, 1990; Froberg and Lammert, 1996).

Froberg and Lammert (1996) suggest that the development of strength can be considered in two phases: the first phase being the prepubertal years until mid-puberty or that age of peak height velocity[3] (PHV) the second phase is from the age of PHV until the end of post-pubertal period (Fig 2.2).

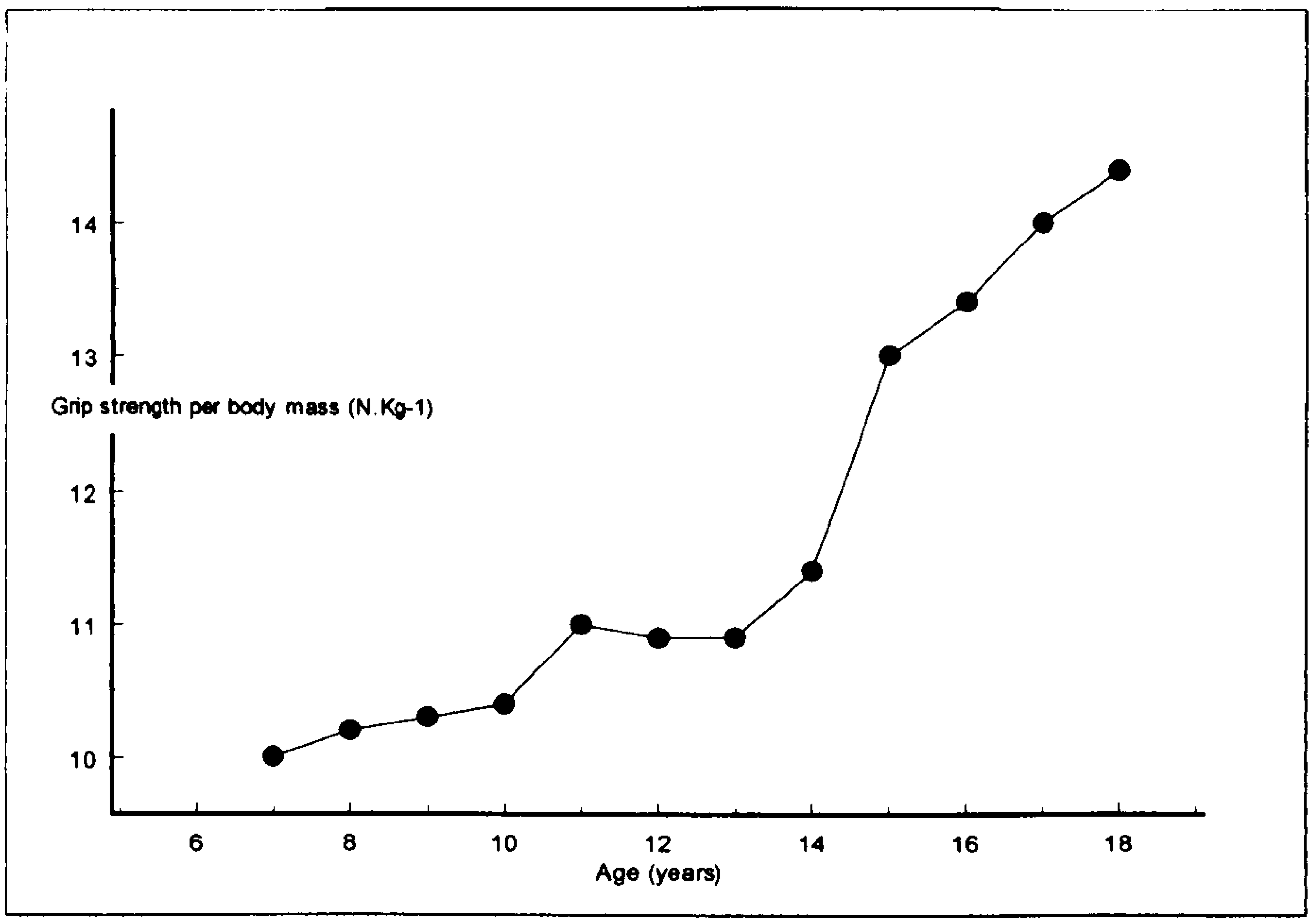

Figure 2.2: Grip strength (N) normalized for body mass (kg) in relation to age. Cited in Froberg and Lammert (1996)

[3] Peak HeightVelocity: The age during the adolescent growth spurt which is associated with the maximum rate of gain in stature (Armstrong and Welsman, 1997)

Whilst there would appear to be a reasonable relationship between strength and chronological age, individual changes in anatomical growth and changes in the internal milieu mean that this relationship is not a simple one (Froberg and Lammert 1996). Maughan (1984) agrees and suggests that individual changes and differences in the internal muscle architecture, limb length and joint structure can affect the maximum force produced by the muscles. Such confounding variables encountered when attempting to measure the effect of growth and maturation on strength and can provide an explanation for the inconsistencies in the literature. Armstrong and Welsman (1997) concur with this suggesting that measurement of strength in children can be affected by biomechanical alterations resulting in changes in both the mechanical advantages of the levers involved in movement and in the structure of the muscle groups.

Authors have investigated the relationship of strength with a number of different growth parameters. Carron and Baily (1974) investigated the relationship between a composite measure of strength in boys from the ages of 10-17 years and height. The observed increase in strength (22.7%) is approximately twice the size of the change calculated when strength was predicted based on changes in weight. Jones and Round (2000) suggest that the longitudinal studies demonstrate that the peak strength development occurs about 1-1.5 years after the age of PHV. However, other authors would suggest that the maximal gains in strength actually coincide more with the age of peak body weight velocity rather than PHV (Lammert, 1982; Beunen and Malina, 1988; Parker *et al.*, 1990).

2.3.2 Anaerobic Power: Growth and Maturation

The anaerobic glycolytic pathway's influence over a 10-metre sprint is less than that of the ATP-PC system (Cerretelli, 1992). The majority of the work investigating the development of anaerobic power due to growth and maturation has concentrated on 30 second tests, such as at the Wingate Anaerobic Power Test (WaNT) or explosive power (eg Sargeant Jump). However the anaerobic glycolytic system does play a role in short duration events such as the 10-metre sprint (Malina and Bouchard, 1991). Peak and mean anaerobic power show a strong positive relationship with chronological age in both boys and girls (Sargeant, 2002; Van Praagh and Dore, 2002). However data for boys do suggest a marked increase from the age of 12-14 possibly as a result of the onset of puberty (Mercier *et al.*, 1991; Armstrong and Welsman, 1997; Sargeant, 2002).

2.4 Agility

During a soccer match players perform almost 1000 different activities per game. They are required to perform sudden changes in direction in combination with rapid movement of limbs (Reilly, 1994). The players movement can be in the horizontal plane (dodging from side to side) or in the vertical plane when the player is jumping or leaping (Tumility, 2000). In order to perform such movements players must demonstrate a good level of agility (Tumility, 2000). Agility can be defined as "*the ability to change body position rapidly and accurately without losing balance*" (Kent, 1994). Its exact nature has not been determined, but it does depend on muscular power, reaction time, co-ordination, dynamic balance and dynamic flexibility (Kent, 1994). A run through cones, designed to represent the movement patterns commonly adopted in soccer, was selected as a measure of agility (Lovell, unpublished).

2.4.1 Development of Control and Co-ordination.

The neuro-musculoskeletal system can develop and improve motor development in children (Watkins, 2000). However, the fundamental motor skills are reasonably well developed in most children by the age of 6 or 7 (Malina and Bouchard, 1991; Watkins, 2000). Further developments can be refined through practice and instruction. As the quality and quantity of performance improve, the patterns are integrated into more complex motor activities (Malina, 1998) such as those demonstrated in soccer.

2.5 Hamstring and Trunk Flexibility

A high level of hamstring and trunk flexibility is considered an important part of injury prevention in soccer, and 79% of muscular strain injuries in soccer players occur in the quadriceps or hamstrings (Price *et al.*, 2003). A recent study (Witvrouw *et al.*, 2003) demonstrated that players who developed hamstring injuries during the season (n= 31) had significantly lower hamstring flexibility at the start of the season than those who did not suffer with hamstring injuries. The sit and reach test is a commonly used test that evaluates trunk, hip and back flexion as well as hamstring flexibility (Borms, 1986). As such it has been included with the anthropometric parameters as a potential confounding variable that may have an effect on the performance in some of the selected fitness tests.

2.6 Measurement of Growth and Maturation

Growth and maturation can have a significant effect on the development of physical fitness (Malina and Bouchard, 1991). Body size can also significantly affect physiological performance measures such as peak aerobic and anaerobic power and muscular strength (Armstrong and Welsman, 1997; Welsman, 1997; Welsman and Armstrong, 2000). It is widely accepted that quantifying the development of growth is necessary if accurate inferences are to be drawn on the changes in physical fitness of children (Armstrong and Welsman, 1997).

Height and weight are most commonly used to measure growth and studies often simply rely upon these measurements (Beunen and Malina, 1996). However much of the variation in human morphology during growth and maturation relates to the development of skeletal, muscle and adipose tissues (Beunen and Malina, 1996). As such methods of monitoring the development of the skeleton, muscle mass and body fat should be included in any such study. Measures of sexual maturity are also, where possible, a useful method of assessing the rate maturation in subjects and there are a number of techniques available for doing this.

The Tanner staging technique is considered the method of choice for monitoring sexual maturation, and is based upon the development of the secondary sex characteristics. However in the current UK political climate there were problems obtaining ethical clearance for using this technique; nor was it possible to use the subjects to assess their own sexual maturity with the Tanner staging photographs (Tanner, 1962).

Alternative methods were therefore investigated for quantifying growth and maturation, in a more detailed way than height and weight alone, which were easy to use with children and adaptable for use by coaches. Somatotyping is a method for describing the human physique in terms of a number of traits that relate to body shape and composition (Duquet and Carter, 2001). It is a non-invasive technique that involves the measurement of condyle width, muscle girth, skinfold thickness, stature and bodymass. The measurements are relatively quick and simple to administer by a trained investigator (Duquet and Carter, 2001). Somatotyping has frequently been used to describe changes in physique during growth and training (Duquet and Carter, 2001), and has been used to identify changes in physique in children (Duquet *et al.*, 1993). Consequently somatotyping was considered a reliable ethically sound and practical method of assessing growth and development.

2.7 Physiology Summary

There is a distinct paucity of literature investigating the physiological load imposed on young soccer players. The majority of the work having been carried out in adult populations, with a consensus that soccer combines speed over a short distance, strength, agility, power and endurance as the main physiological components, although the specific contributions of each energy systems remains unknown (Casajus, 2001).

This review of literature has highlighted that, whilst there is conflicting evidence surrounding the efficacy of fitness training in young participants, there is a body of evidence to suggest that aerobic capacity (Obert *et al.,* 2001), sprint performance (Blimkie and Bar-Or, 1996) and agility (Malina, 1998) may be improved with sufficient specific physical stimulus. When participating in soccer young children have been shown to exhibit heart rates in excess of 200bpm for longer than 40% of the total duration of a match, and to perform several short periods of maximal sprinting (Donoghue, 2003). Consequently participation in competitive soccer may provide a sufficient physical stimulus to result in improvements in physical fitness.

The literature reviewed has enabled the identification of the main fitness components, listed above, and thus enabled the selection of appropriate field tests to monitor the changes in physical fitness in young soccer players. There is limited literature on the effect of competitive soccer on the fitness of young participants. Mosher *et al.,* (1985) and Berg *et al.,* (1985) both failed to show any improvements in fitness during relatively short studies. However this may be as a result of the short duration of the studies and the use of simulated matches where the work load may be lower. This study aims to examine the changes over a full soccer season of 42 weeks in duration and the effect of participation in competitive matches on the fitness of young soccer players.

3. Psychology: Review of Literature

The review of literature has highlighted that soccer is a high intensity sport and young players demonstrate heart rates in excess of 170 bpm for more than 80% of a soccer match. Researchers have been investigating the effect of high intensity exercise participation on mood for a number of years (Terry, 2000). However, the effect of long-term participation in competitive soccer, on the mood of young players, has yet to be investigated.

For the purposes of this thesis it should be noted that the term "mood" refers to the mood construct as operationalized by the authors of the Profile of Mood States (POMS). Subsequently mood refers to a host of transient, fluctuating affective states that reflect how an individual feels in general or globally at a particular moment in time (McNair *et al.*, 1971; 1992).

3.1 Mood States - Sports and Exercise

The quest to understand the effect of sport and exercise on the psychology of emotion has generated persistent investigation of the construct of mood (Terry *et al.*, 1999).

There is strong evidence to show that moderate intensity exercise, between 60 and 80% of estimated maximum heart rate, is associated with a decrease in stress-related emotions such as anxiety (Morgan, 1985) and depression (Greist *et al.*, 1979). However, other investigations examining the effect of participation in competitive sport have found moods to show a varied response (Berger and Owen, 1983; Gutmann *et al.*, 1984; Raglin *et al.*, 1991; Hooper *et al.*, 1997). Such investigations have shown that during training for competition mood improves during lower training load periods (ie periods of lower physical stress). Mood then deteriorates with periods of overreaching[4] and continues to deteriorate as overtraining syndrome[5] develops (Berger and Owen, 1983; Gutmann *et al.*, 1984; Raglin *et al.*, 1991; Hooper *et al.*, 1997).

It would therefore appear that physical exercise and sport can have both a beneficial and a negative affect on mood. Periods of overload/overreaching and overtraining are associated with mood disturbance but moderate intensity exercise results in improvements in mood with both competitive athletes and previously sedentary subjects (Morgan, 1985; Berger and McInman, 1993; Berger, 1996; Morgan, 1997; Berger and Molt, 2000). The suggestion that mood states can reflect the overall physical stress experienced by athletes has therefore led researchers to investigate the use of mood states as a measure of physical stress from training and participation in sport (Terry, 1995).

3.1.1 Monitoring of Training Load and Physical Stress with Mood

Research into the relationship between sport, physical exercise and mood has commonly observed the effect of the physical stress imposed on athletes during their training. References to the physical stress as a result of training is referred to simply as "training load".

Terry (1995) proposed that mood profiling can be used as a systematic method of monitoring training load. There have been a number of investigations into the relationship between training load (physical stress) and mood states (Berger and Molt, 2000)

In 1987 Morgan *et al.,* (1987) published the results of a series of studies investigating the effect of swim training on mood. The

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[4] Overreaching – short term period of physical overload often used to stimulate positive training response Fry, A. C. and W. Kraemer (1997). "Resitance exercise overtraining and overreaching." Sports Medicine 23(2): 106-129.

[5] Overtraining syndrome – An accumulation of training or non-training stress resulting in long-term decrement in performance capacity with or without related physiological and psychological signs and symptoms of overtraining. Ibid.

investigations included both male and female university swimmers, and observed the changes in mood every two to four weeks over different phases of the training cycle (Morgan *et al.*, 1987). The research demonstrated significant increase in the total mood disturbance (TMD). This is consistent with a dose-response manner when compared to alterations in training volume (e.g. distance in metres). The changes in TMD observed in the studies occurred as a result of the changes in vigour, fatigue, tension and depression. This suggests that whilst the physical stress from training induces an increase in TMD the affected individual mood states may vary between subjects.

Morgan *et al.,* (1987) used students who did not participate in swim training as controls, to see if the mood changes were a response to external stressors such as exams. Results demonstrated that there were greater increases in TMD in the group of swimmers compared with the control group, who showed no significant changes in mood over the testing period. Thus it was concluded that the changes in TMD were a response to the increasing training volumes (Morgan *et al.*, 1987).

This is consistent with the work of Gutmann *et al.,* (1984) who observed 11 male contenders for the USA Winter Olympic speed skating team. The skaters were evaluated repeatedly during the six months of training before the Olympic winter trials. The primary purpose of the study was to examine the effects of prolonged high-intensity training and competition on both physiological and psychological states. The skaters selected for the 1980 Olympic team responded to training with decreasing depression and increasing vigour, reaching a psychological peak just before the trials. Those not selected fluctuated much more in mood and never recovered to pre-training levels of vigour (Gutmann *et al.*, 1984).

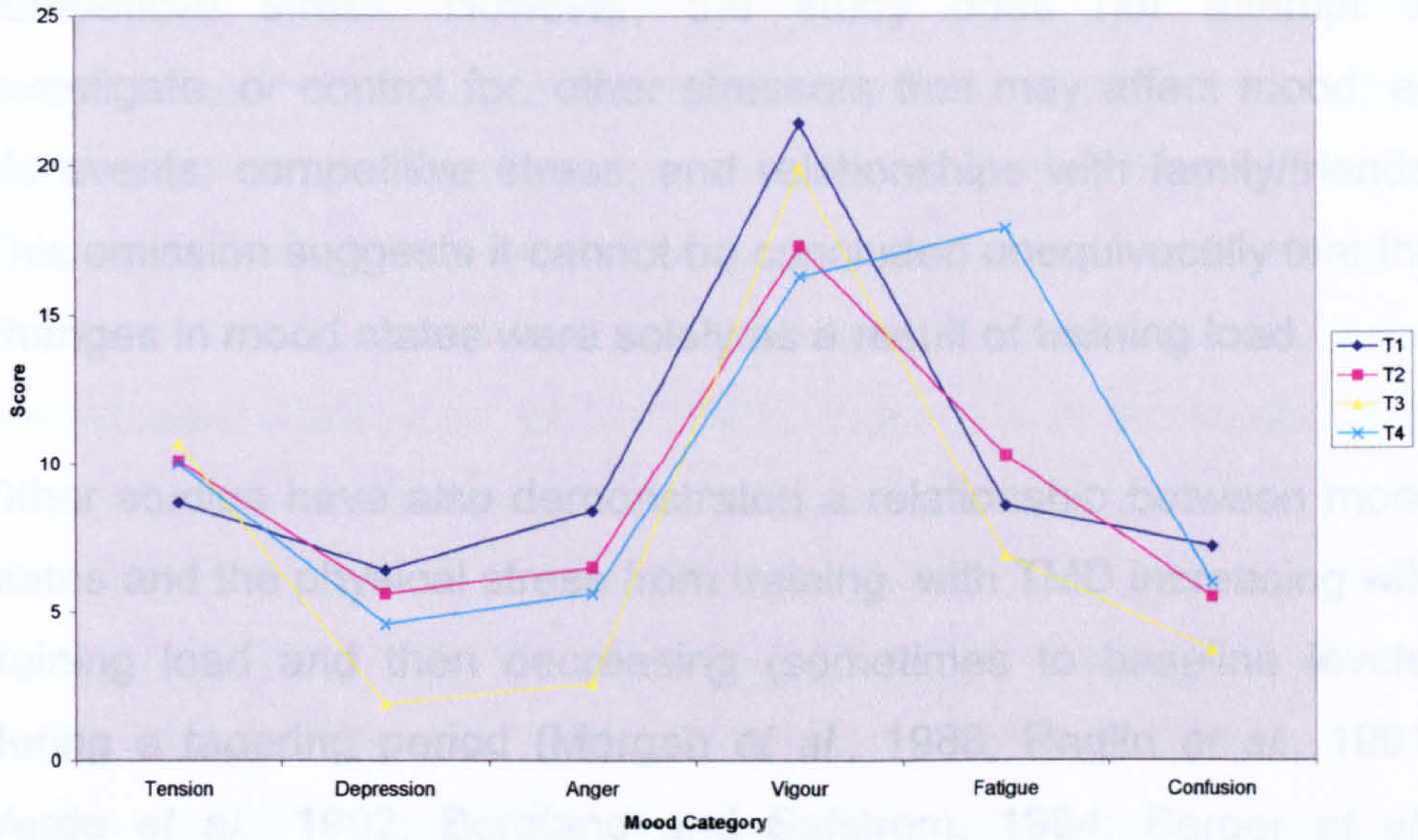

Figure 3.1: Mood state changes during competitive Olympic Speed Skating Season.

At the start of the study (T1) the group, as a whole, showed the iceberg profile of other world class sportsmen. At the end of summer training (T2) the profile flattens with an increase in tension and fatigue and a decrease in vigour. At T3, just before the trials the skaters reported more vigour and less fatigue, depression and anger. Immediately after the trials (T4) the skaters returned to a psychological state similar to that found at T2 except for more pronounced level of fatigue (Fig 3.1) (Gutmann *et al.*, 1984).

The results from this study suggest an initial improvement in mood in response to the training load. However, as the training load increased there was an increase in TMD as a result of increases in tension, depression, and fatigue with a decrease in vigour (Gutmann *et al.*, 1984). An additional aspect of this study was to compare the coping strategies the athletes employed to deal with the stress of competition and the Olympic trials. This showed that those with the more comprehensive strategies showed less mood disturbance and performed better in the trials (Gutmann *et al.*, 1984). This work highlights the fact that physical stress from exercise or training is not the only factor that can affect mood and has attempted to investigate how effective athletes' coping strategies are at dealing with competitive stress. However, the study does not attempt to investigate, or control for, other stressors that may affect mood; eg life events; competitive stress; and relationships with family/friends. This omission suggests it cannot be concluded unequivocally that the changes in mood states were solely as a result of training load.

Other studies have also demonstrated a relationship between mood states and the physical stress from training with TMD increasing with training load and then decreasing (sometimes to baseline levels) during a tapering period (Morgan *et al.*, 1988; Raglin *et al.*, 1991; Verde *et al.*, 1992; Bergland and Safstrom, 1994; Berger *et al.*, 1999). However few of these studies have explored additional stressors, such as home life, which ought to be assessed if moods are to be used as a marker of physical stress.

Authors such as Morgan *et al.*, (1987), and Berger and Molt (2002) have consistently highlighted the role of "external stressors". These include divorce (Copeland, 1985) and relationships with friends and work colleagues (Stone, 1987), on mood states but few studies have attempted to use a control group or to identify the sources of stress affecting a performer (Morgan *et al.*, 1988; Raglin *et al.*, 1991; Berger *et al.*, 1999; Beedie *et al.*, 2000; Berger and Molt, 2000).

3.1.2 Variables Affecting Mood States

Mood can be affected by either the body's physiological or psychological arousal systems (Thayer, 1996). These range from simple metabolic processes and elemental biochemical reactions to more complex psychophysiological systems – the cardiovascular, respiratory, skeletal-muscular, and endocrine systems (Parkinson *et al.*, 1996; Thayer, 1996).

As suggested previously mood states are not solely a mental reaction, for example when tired it is difficult to separate how the body feels (run down, hungry, in need of sleep) from how the mind feels (edgy, distracted) (Thayer, 1996). Parkinson *et al.,* (1996) suggest that mood can be affected by three categories; events and situations that can be regarded as external to the person: factors seen as internal to the person, such as personality; and factors that are as a consequence of transactions between the person and the environment (Parkinson *et al.*, 1996). Examples of the factors that influence an individual's mood include: relations with family (Copeland, 1985) and friends (Stone, 1987); work or school life (Rushall, 1990); health of both the individual and others; bereavement (Parkinson *et al.*, 1996); the weather and participation in exercise (Morgan, 1997). If, as in the case of this thesis, an attempt is being made to monitor the effect of sports participation on mood, investigators must attempt to control for the additional factors that can affect mood (Morgan *et al.*, 1987). The Daily Analysis of Life Demands for Athletes (DALDA; (Rushall, 1990)) has been identified as a method of monitoring both the sources and symptoms of commonly experienced stress by athletes. It was selected to be used in conjunction with the BRUMS, to allow the identification of the sources of stress experienced by the subjects.

3.1.3 Psychology - Summary

This review of literature has highlighted the general consensus that the physical stress from exercise at moderate intensity and at the start of a training plan can result in improvements in mood. When exercise is a sufficient intensity to initiate a period of "physical overload" the total mood disturbance score increases due to a decrease in vigour and an increase in negative mood states eg fatigue, tension, and anger. This relationship between mood and training load is demonstrated in a dose response manner.

The evidence presented, that mood states can reflect training load/stimulus and the suggestion that mood is a reliable marker of overtraining syndrome, has lead authors to suggest that physical stressors can be quantified by the monitoring of mood states. This would allow coaches to titrate training loads on an individual basis (Urhausen *et al.*, 1998; Berger *et al.*, 1999; Budgett *et al.*, 2000; Meehan *et al.*, 2002; Urhausen and Kinderman, 2002). During this study the BRUMS will be used to investigate if the physical stress, as a result of competitive soccer is sufficient to result in an increase in total mood disturbance (TMD) and to identify if there is any difference in the physical stress between the restricted and unrestricted season. There is a distinct lack of research investigating the effect, on mood, of participation in elite youth team soccer.

The review has also highlighted the fact that stressors, other than training stress, may play a role in mood changes and that few studies have attempted to identify the sources of stress when examining the effect of exercise on mood. As a result of this the Modified Daily Analysis of Life Demands in Athletes (Ryder *et al.*, 2001) is used in order to identify additional sources of stress that might result in increases in TMD.

4. Immunology: Review of literature

Competitive soccer matches have been shown to elicit heart rates in excess of 170bpm in young participants (Drust and Reilly, 1997; Capranica *et al.*, 2001) and to include several burst of high intensity exercise (O'Donoghue, 2003). Research into the effect of high intensity exercise on immune function has suggested that participants are more susceptible to infection (Mackinnon, 1999). It is therefore plausible that participation in competitive soccer might result in a decreased immune response and thus increased risk of infection with upper respiratory tract infections (URTIs).

There are two reported possible outcomes of exercise participation on immune function depending on the exercise intensity: regular moderate intensity exercise is purported to decrease an individuals susceptibility to develop infectious illnesses such as the common cold (Mackinnon, 1999). Nieman *et al.,* (1990b; 1998) showed that brisk walking resulted in moderately overweight women demonstrating significantly less URTIs than the sedentary controls. Karper and Boschen (1993) and more recently Klentrou *et al.,* (2002) have provided supporting evidence that people who participate in moderate intensity exercise are less likely to suffer from URTIs than sedentary control groups. Conversely, research investigating the effect of high intensity training has demonstrated that participants are more susceptible to infection (Mackinnon, 1999). This has been demonstrated in a number of studies: Peters and Bateman (1983) studied 100 runners and showed that the incidence of URTI was two times higher than age-matched non-runners in the same household. These findings have been supported by a number of authors, who have shown that athletes are between two and six times more likely to suffer from URTI than controls (Linde, 1987; Nieman *et al.*, 1990a; Peters, 1990; Heath *et al.*, 1991).

Nieman and Nehlsen-Cannanella (1992) have suggested a "J-Shaped" model to explain the association between exercise and infectious disease (Fig 4.1). This model proposes that the relative risk of infection decreases as exercise intensity increases from that of a sedentary individual up to a moderate intensity, but as the intensity levels continue to increase the relative risk of infection increases (Nieman and Nehlsen-Cannarella, 1992). This hypothesis has been supported by Heath (1991) and more recently Klentrou (2002).

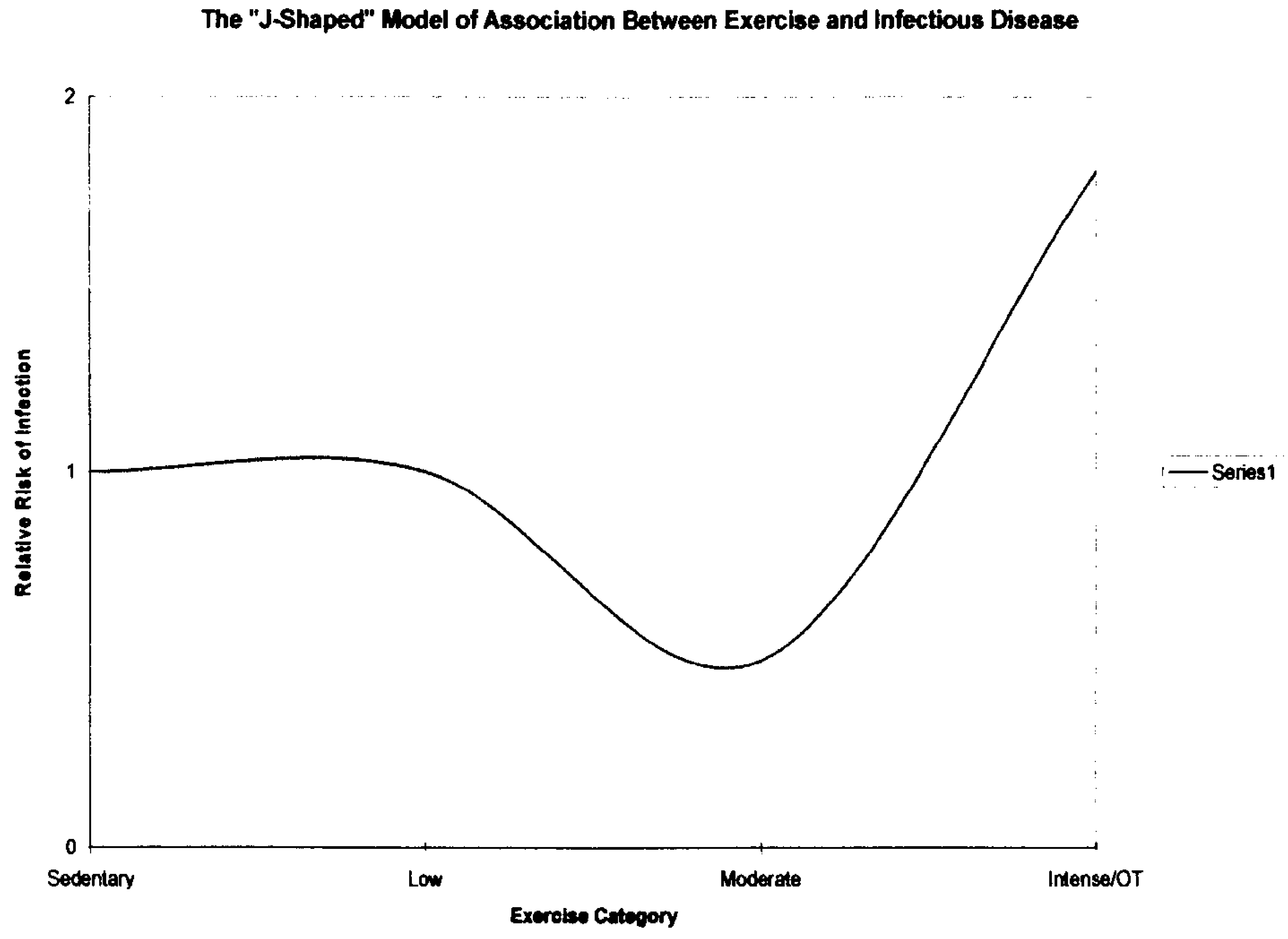

Figure 4.1: Schematic representation of relative risk of infection plotted against increasing levels of physical exertion (Modified from (Nieman and Nehlsen-Cannarella, 1992))

The investigations into exercise and incidence of infection have led researchers to attempt the identification of mechanisms and markers behind the relationship between exercise and immunology. Such investigation includes studying the effect of exercise on mucosal immunoglobulin a (IgA) (Mackinnon, 1999), as mucosal IgA plays an important role in the resistance to viral infection (Nieman and Nehlsen-Cannarella, 1991; Nieman and Nehlsen-Cannarella, 1992; Mackinnon, 1999; Klentrou *et al.*, 2002). This is due to its ability to prevent the invading organism from attaching to and penetrating the epithelial surface (Benjamini *et al.*, 2000) .

4.1 IgA as a Marker of Immune Function

Immunoglobulin (Ig) is a generic term given to a class of glycoproteins that are produced by β and plasma cells. It is found in both serum and other body fluids such as tears and saliva (Mackinnon, 1999; MacKinnon, 2000). These glycoproteins carry out antibody activity and respond to and combine with specific antigens

(Nieman and Nehlsen-Cannarella, 1991). These antibodies "tag" the antigens and effectively label the foreign molecules for destruction by various effector mechanisms (Gleeson and Bishop, 1999). There are five types of Immunoglobulins, IgM, IgG, IgA, IgD and IgE (Nieman *et al.*, 1990b; Nieman and Nehlsen-Cannarella, 1991; Nieman and Nehlsen-Cannarella, 1992; Mackinnon, 1999; MacKinnon, 2000). Secretory IgA acts as a first line of defence against colonization of infectious agents on mucosal surfaces and is regarded as an important element used in the prevention of URTI (Gleeson, 2000). IgA is the predominant Ig in mucosal secretions and saliva and, along with IgM and IgG has been measured in a number of investigations in exercise immunology (Mackinnon, 1999).

4.1.1 Exercise and IgA

Mackinnon (1999) indicates that serum and mucosal Ig are independently regulated and often respond in different ways to exercise, and should be considered separately. The level of secretory IgA contained in mucosal fluids (such as saliva) correlate, more closely than serum antibodies with resistance to URTI (Murphy *et al.*, 1982; Liew *et al.*, 1984; Tomasi and Plaut, 1985). Given the applied nature of this thesis and ethical concerns associated with obtaining blood samples from children saliva sampling was selected as a method for assessing immune function on account of the non-invasive sampling technique and suitability for the sport and subject population (Mackinnon, 1999; MacKinnon, 2000). Salivary IgA was selected as a marker of immune function as it is the predominant Ig in mucosal secretions.

4.1.2 Moderate Intensity Exercise

Research examining the effect of prolonged participation in moderate intensity exercise has shown either an increase or no significant change in resting salivary IgA levels (Mackinnon, 1999). Nieman *et al.*, (1990b) showed that walking briskly for 45 min, five days a week over a 15 week training period for moderately overweight women resulted in a significant lower incidence of URTI. They repeated this protocol in obese women (Nieman *et al.*, 1998) and again showed a significantly lower incidence of URTI in the exercise group than the controls with no change in the immunological measurements studied. Karper (1993) also reported a lower incidence of URTI in subjects who participated in moderate exercise training over the course of one year. However none of the studies outlined above investigated changes in salivary IgA.

Recently Klentrou (2002) investigated the effect of 12 weeks moderate exercise training in previously sedentary subjects. In this study subjects participated in three exercise sessions per week, consisting of 30 minutes of aerobic exercise (at 75% of maximal heart rate) and 15 minutes of stretching. Measurements of aerobic fitness (PWC 150 test), and salivary IgA were taken at the start (week 0), midpoint (week 6) and the end of the programme (week 12). Subjects were also asked to record symptoms of health problems daily, throughout the 12 weeks.

At the midpoint of the training programme the exercise group recorded significantly higher numbers of moderate symptoms of URTI than the controls. After the 12 weeks of regular exercise the overall number of light symptoms was significantly reduced in the exercise group with absolute IgA increasing by 36.5% in the exercise group and decreasing slightly in the control group (Klentrou *et al.*, 2002).

The authors suggest these findings may have been a result of the training programme, initially, being at too greater intensity. The subjects had been sedentary and 30 minutes exercise at 75% of the maximum heart rate may have been too strenuous at the start of the programme thus having a negative effect on their immune system. However as the training continued and fitness improved the immune system appeared to strengthen (Klentrou *et al.*, 2002). This was demonstrated with the positive relationship between changes in aerobic capacity and IgA (Klentrou *et al.*, 2002), a finding the authors suggest supports the "J-Shape" Hypothesis suggested by Nieman (Nieman and Nehlsen-Cannarella, 1992).

The research has demonstrated that participation in moderate intensity exercise will strengthen the resistance of the immune system to URTI's in previously sedentary individuals. However there is surprisingly little research investigating the effect of moderate intensity exercise on salivary IgA concentrations.

4.1.3 High Intensity Exercise

As outlined previously, endurance athletes have been shown to be more susceptible to URTIs than non-athletes (Peters and Bateman, 1983; Linde, 1987; Nieman *et al.*, 1990a; Peters, 1990; Heath *et al.*, 1991). Findings of studies investigating exercise and URTIs have suggested that salivary IgA may also be affected by exercise participation, and that high intensity exercise may reduce resting salivary IgA levels and thus increase the risk of URTI (Mackinnon, 1999).

Some cross sectional studies have shown athletes to have significantly lower resting salivary IgA levels than non-athletic controls (MacKinnon, 2000). Tomasi *et al.*, (1982) showed that elite Nordic skiers demonstrated a 50% lower resting salivary IgA concentration when compared with age-matched non-athletes. They suggested this was due to both the intense training and possibly the psychological stress of competition (Tomasi *et al.*, 1982). However other authors (Mackinnon *et al.*, 1989) have shown athletes to have resting salivary IgA levels similar to age-matched non-athletic controls. Mackinnon (1989) showed no significant difference in resting salivary IgA concentrations between trained cyclists and sedentary controls although the authors suggest the difference in these findings might be due to the cyclists not being "elite" athletes and not being tested immediately prior to competition. Gleeson *et al.,* (1995) investigated the effect of long term swim training on the immunity of elite swimmers and showed an increased incidence of URTI and a chronic suppression of the immune system but showed no difference in salivary IgA concentrations between the training and control groups. However, the weakness of this cross-sectional approach is that there is great individual variability in any immune parameter that may not be revealed by a single measurement at only one particular point in time (MacKinnon, 2000).

Other authors have measured athletes repeatedly over a training season and examined changes in salivary IgA concentration with training load. This has provided useful information about the effects of exercise training or volume and/or intensity of immune function in the athlete's natural environment (MacKinnon, 2000).

Tharp and Barnes (1990) showed that resting salivary IgA concentrations decreased by 25% from early to late season as training increased from light to heavy, with a partial recovery during reduced training leading up to a major competition. Gleeson (1995) also demonstrated progressively decreasing resting (and post-exercise) salivary IgA over a 7-month swimming season. Further research with swimmers by Mackinnon and Hooper (1994) studied salivary IgA relative to total salivary protein in elite Australian swimmers. They showed a significant reduction throughout a six month competition season in athletes who showed symptoms of overtraining compared to their well trained peers (non-overtained) (Mackinnon and Hooper, 1994). However whilst these studies are well controlled there are limitations associated with the expression of values for salivary IgA as either absolute or relative to total protein, which may have affected the results (Blannin *et al.*, 1998).

The literature investigating salivary IgA concentration in athletes appears to agree that prolonged participation in high intensity endurance exercise training is associated with a chronic and cumulative decrease in salivary IgA concentrations (Mackinnon, 1999). The magnitude of this decrease is related to the intensity of the exercise.

4.2 Cortisol

4.2.1 Cortisol as a Marker of Stress

When examining the effects of exercise on immunological parameters some account must be made as to the additional stressors that might affect immunity. As outlined previously a modified version of Rushall's (1990) Daily Analysis of Life Demands on Athletes was used to identify what the subjects perceived as being the sources of their stress (Ryder *et al.*, 2001). However this scale only allows subjects to identify if the "sources of stress" were normal, worse than normal, or better than normal. The questionnaire did not quantify the total level of stress the subjects were being subjected too.

A second method of quantifying the stress levels individuals are subjected to is by using salivary cortisol (Pollard, 1995). This has been shown to be an objective marker of stress and as such would allow a quantification of the overall stress levels being experienced by the soccer players (Baum *et al.*, 1982; Kirschbaum and Hellhammer, 1989).

Cortisol is a corticosteroid secreted from the adrenal cortex (Kirschbaum and Hellhammer, 1989; Pollard, 1995). It is released in response to various physiological agents and psychosocial stimuli (Kirschbaum and Hellhammer, 1989). The results of investigations on the influence of a variety of stressors on salivary cortisol appear unequivocal, with exposure to stressors resulting in increases in salivary cortisol concentrations (Vedhara *et al.*, 2003). Examples of stressfull situations shown to increase cortisol levels include: horror films (Hellhammer *et al.*, 1986); flying (Kakimoto, 1985) (Cited in

(Kirschbaum and Hellhammer, 1989)); and performing mental arithmetic and public speaking (Holl *et al.*, 1984) and physical exercise (Nieman, 1994). Bassett *et al.,* (1987) investigated the effect of delivering a 15-minute lecture in front of an audience, on salivary cortisol levels, in bank employees. Salivary cortisol levels were significantly higher in the period immediately prior to the presentation and remained elevated for two hours (Bassett *et al.*, 1987). These findings have been supported by Lehnert (1989) who demonstrated a significant increase in cortisol levels prior to a public lecture with levels peaking after the 10-minute preparatory phase. Cortisol has also been shown to increase in response to academic examination (Jones *et al.*, 1986). In this study 40 medical students gave three saliva samples independently three days before the test and on the day of examination. Results demonstrated an increase in salivary cortisol concentration immediately prior to the examination, when compared to a control day (Jones *et al.*, 1986).

Research investigating the effect of exercise on salivary cortisol levels has shown that exercise at an intensity level greater than 70% of the subjects' maximal aerobic capacity increases salivary cortisol levels (Kirschbaum and Hellhammer, 1989; 1992). This work is supported by Stupnicki and Obminski (1992), who showed that salivary cortisol levels increased from 17.9 to 22.7 $nmol^{-1-1}$ in athletes from a variety of sports exposed to a laboratory based bout of high-intensity exercise. DelCorral *et al.,* (1994) investigated the effect of a 30-minute bout of exercise at 70% of VO_2 max in male children (mean age 10.6 years sd 0.2 yr). This work demonstrated that an exercise bout similar in nature to that suggested by Kirschbaum *et al.,* (1992) increases salivary cortisol concentrations in children.

Having identified the acute response of salivary cortisol to exercise, researchers have investigated the usefulness of resting cortisol levels as markers of training status. Results have indicated that resting values remained stable as training intensity increased (Flynn *et al.*, 1994; Urhausen and Kinderman, 2002), and that findings are equivocal when using salivary cortisol as a marker of overtraining syndrome (Flynn *et al.*, 1994; Urhausen *et al.*, 1995; Urhausen and Kinderman, 2002). With some papers claiming resting cortisol levels to be lowered when in an overtrained state (Neary *et al.*, 1994) and others demonstrating raised cortisol in overtrained athletes (Flynn *et al.*, 1994). As demonstrated with the earlier literature on salivary IgA, some of the conflicting results may be as a result of changes in the saliva flow rate, thus producing altered salivary cortisol levels.

4.3 Immunology Summary

This review of literature has highlighted the limited amount of work investigating the effect of both moderate and high intensity exercise training on the incidence of URTI and salivary IgA concentrations.

Moderate intensity exercise has been shown to either increase (Mackinnon, 1999) or have no effect on the risk of URTI and that prolonged participation in high intensity training with inadequate recovery results in an increased risk of URTI (Peters and Bateman, 1983; Heath *et al.*, 1991).

Salivary IgA acts as a first line of defence against colonization of infectious agents on mucosal surfaces (Mackinnon, 2000). It is regarded as an important element used in the prevention of URTI and has been shown to correlate with resistance to URTI (Murphy *et al.*, 1982). Research investigating the effect of exercise on salivary IgA has shown that moderate intensity exercise either increases or has no affect on resting salivary IgA concentrations. Prolonged participation in high intensity exercise with inadequate recovery may also result chronic suppression of salivary IgA levels (Gleeson and Bishop, 1999).

The mechanisms behind the reduction in salivary IgA remains uncertain. However, it has been suggested that chronic suppression of IgA occurs as a result of failure to recover from the acute decrease caused by high intensity exercise, prior to performing repeated bouts similar exercise (Mackinnon, 1999).

Authors have highlighted the methodological problems associated with the measurement of salivary IgA. This includes the effect of psychological stress on immune function and the poor reliability of citing salivary IgA concentrations as either absolute values or relative to total protein or albumin.

The vast majority of this work has been carried out in endurance sports such as swimming. There is distinct lack of work investigating the effect of participation in elite youth team soccer during a competitive season. The question as to whether reducing the number of games children participate in has any effect on the salivary IgA concentrations in children as yet remains unanswered.

It has been suggested that resting salivary IgA levels will provide a marker of immune function and allow an investigation into the effect of prolonged soccer participation on immune function in young soccer players. Resting salivary cortisol levels will also be used as a marker of overall stress in an attempt to control for the additional stressors the subjects may be subjected to.

5. Aims and Hypothesis

The review of literature has highlighted the high intensity nature of competitive soccer, and the contribution from both the aerobic and anaerobic energy systems. The review has also highlighted the, potential effect of prolonged exposure to this physical stimulus on the physical fitness, mood states and immune system of young participants. Consequently the following aims, objectives and hypothesis were developed.

5.1 Aims and Objectives

The aim of this thesis was to utilize a multidisciplinary approach to investigate the effect of participation in competitive soccer and to evaluate the effect of limiting the number of competitive games young players are allowed to participate in has on the:-

- the subject's physical fitness
- the subject's mood states
- the subject's immune function
- qualitative and quantitative makers of stress

5.2 Hypotheses:

The following hypotheses have been tested in this thesis:

5.2.1 Physiology

Aerobic Capacity

There is an increase in aerobic fitness across an unrestricted soccer season as a result of the physical stimulus from participation in competitive soccer.

Limiting the number of games young soccer players participate in to 36 results in a smaller increase in aerobic capacity than is effected by an unrestricted season.

Sprint Performance

There is a decrease in time taken to sprint 10 metres across an unrestricted soccer season as a result of the physical stimulus from participation in competitive soccer.

Limiting the number of games young soccer players participate in results in a smaller improvement in sprint performance than is effected by an unrestricted season.

Agility Run Performance

There is a decrease in time taken to complete a run through cones across an unrestricted soccer season as a result of participation in competitive soccer.

Limiting the number of games young soccer players participate in results in a smaller decrease in the time taken to complete a run through cones than is effected by an unrestricted season.

5.2.2 Psychology

There is an increase in total mood disturbance across an unrestricted season as a result of participation in competitive soccer.

Limiting the number of games young soccer players participate in results in a smaller increase in total mood disturbance than is effected by an unrestricted season.

5.2.3 Immunology

There is a decrease in resting salivary IgA concentrations across an unrestricted season as a result of participation in competitive soccer.

Limiting the number of games young players participate in results in a smaller decrease in resting salivary IgA than effected by an unrestricted season.

6. Methods

6.1 General Methods

6.1.1 Subject Numbers

All subjects were recruited from a local Nationwide Football League Club, and all players were registered with the Club's Centre of Excellence in season one, and with the newly developed Academy in season two. The between seasons comparison was made between similar age groups, eg under 11 season one versus under 11 season two.

Table 6.1: Subject Numbers (n) and average age (Years)

Age Group	Season 1 (n)	Season 1 Age Yrs (sd)	Season 2 (n)	Season 2 Age Yrs (sd)
Under 11	12	10.48 Yrs (.18)	14	10.52 Yrs (.32)
Under 12	14	11.38 Yrs (.34)	14	11.49 Yrs (.33)
Under 13	16	12.55 Yrs(.37)	16	12.47 Yrs (.30)
Under 14	15	13.40 Yrs (.27)	14	13.38 Yrs (.24)
Under 15	24	14.46 Yrs (.28)	24	14.50 Yrs (.27)

The specific subject numbers included in each of the analyses will be given in the individual chapters.

6.1.2 Testing Timetable

The testing was carried out every six weeks in the first season of the study and every eight weeks during the second season of the study. Both seasons were 42 weeks in duration, with baseline data for each season being collected on the week prior to pre-season training. One age group was tested per day, with each age group being tested on the same day of the week and at the same time throughout the duration of the study.

6.1.3 Ethical Considerations

All of the investigators involved in the study were required to undertake a Criminal Records Bureau check (CRB), with all subjects and their parents completing an informed consent form, outlining the purposes of these tests and the risks involved (Appendix A). To ensure confidentiality, all data were coded and stored on file in the investigator's office and only those directly involved in the project were granted access to the data.

All subjects undertook a full medical examination, prior to the start of any testing, by the club doctor. Ethical approval was obtained from the Chester College Ethics Committee.

6.2 Anthropometric Measurements

6.2.1 Height

The subjects' height was measured without their shoes and stockings, to the nearest 0.1 centimetre (cm) using a Seca stadiometer (Birmingham, UK).

6.2.2 Weight

The subjects' weight was measured in only their club shorts, in kilograms (kg), using an analogue scale (Salter, UK) to the nearest 10g.

6.2.3 Somatotyping

Somatotype characteristics of were calculated using the Heath-Carter somatotype method (1989) with skinfold sites located in accordance with the BASES (1997) guidelines. The validity of this technique with children has been previously demonstrated (Duquet and Carter 2001).

The measurements included: tricep, subscapular, and supraspinale skinfold measurements, biepicondylar humerus and biepicondylar femur breadth, upper arm and standing calf girth.

1. The measurements were taken on dry skin.
2. The subject was asked to keep the muscles relaxed during the tests.
3. All measurements were taken on the right hand side of the body.
4. The skinfold sites were marked with a water-soluble ink pen, and a metal tape measure was used to find the midpoints of each selected skinfold sites accurately.
5. The skinfold was firmly grasped by the investigator's thumb and index finger, using the pads at the tip of the thumb and finger. The skinfold was then gently pulled away from the body.
6. The callipers were placed perpendicular to the fold, on the marked site, dial facing up, at approximately 1 cm below the finger and thumb. While maintaining the grasp of the skinfold, the callipers were then fully released to maintain tension on the site. The dial was then read to the nearest 0.50mm, 1-2 seconds after the grip has been released.
7. Two tests were taken at each site. If the tests varied by more than 1 mm, the measurements were repeated.
8. There were 15 seconds rest between each test on the same site.
9. The final value recorded was an average of the two closest and represented the skinfold fat site.

(BASES, 1997)

The following formulae were used in order to calculate the anthropometric Heath-Carter Somatotype (Duquet and Carter, 2001):

Endomorphy = $-0.7812 + 0.1451X - 0.00068X^2 + 0.0000014X^3$

Where X = the sum of the tricep, subscapular, and supraspinale skinfolds corrected for height[1].

Mesomorphy = $0.858HB + 0.601FB + 0.188AG + 0.161CG - 0.131SH + 4.5$

Where HB = humerus breadth; FB = femur breadth; AG = corrected arm girth[2]; CG = corrected calf girth; SH = standing height.

Ectomorphy = $0.732HWR - 28.58$ (if $HWR > 40.74$)

= $0.463HWR - 17.615$ (if $39.65 < HWR \leq 40.74$)

= 0.5 (if $HWR \leq 39.65$)

Where HWR = height over cube root of weight.

Following this a sompatotype category was identified using the Heath and Carter (1990) definition.

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6.3 Performance/Fitness Parameters

6.3.1 Agility

Agility was assessed using a "run through cones" test, covering a distance of 27 metres as used by the English Football Association (FA). The validity and reliability of this test, for use with children has been previously demonstrated (Lovell, unpublished) (Figure 6.1).

Prior to measurement. the subjects were allowed four practice runs to become habituated. Subjects then completed the course twice and the average time was calculated using the Newtest Power System (2000 Newtest Oy – Finland) if the two scores were within 0.5

[1] Correct for height by multiplying this sum by 170.18/height (cm)

[2] Correct muscle girth measurements by subtracting appropriate skinfold measurement

seconds of each other. If the difference between runs was greater than 0.5 seconds, the subject was asked to undertake a further test.

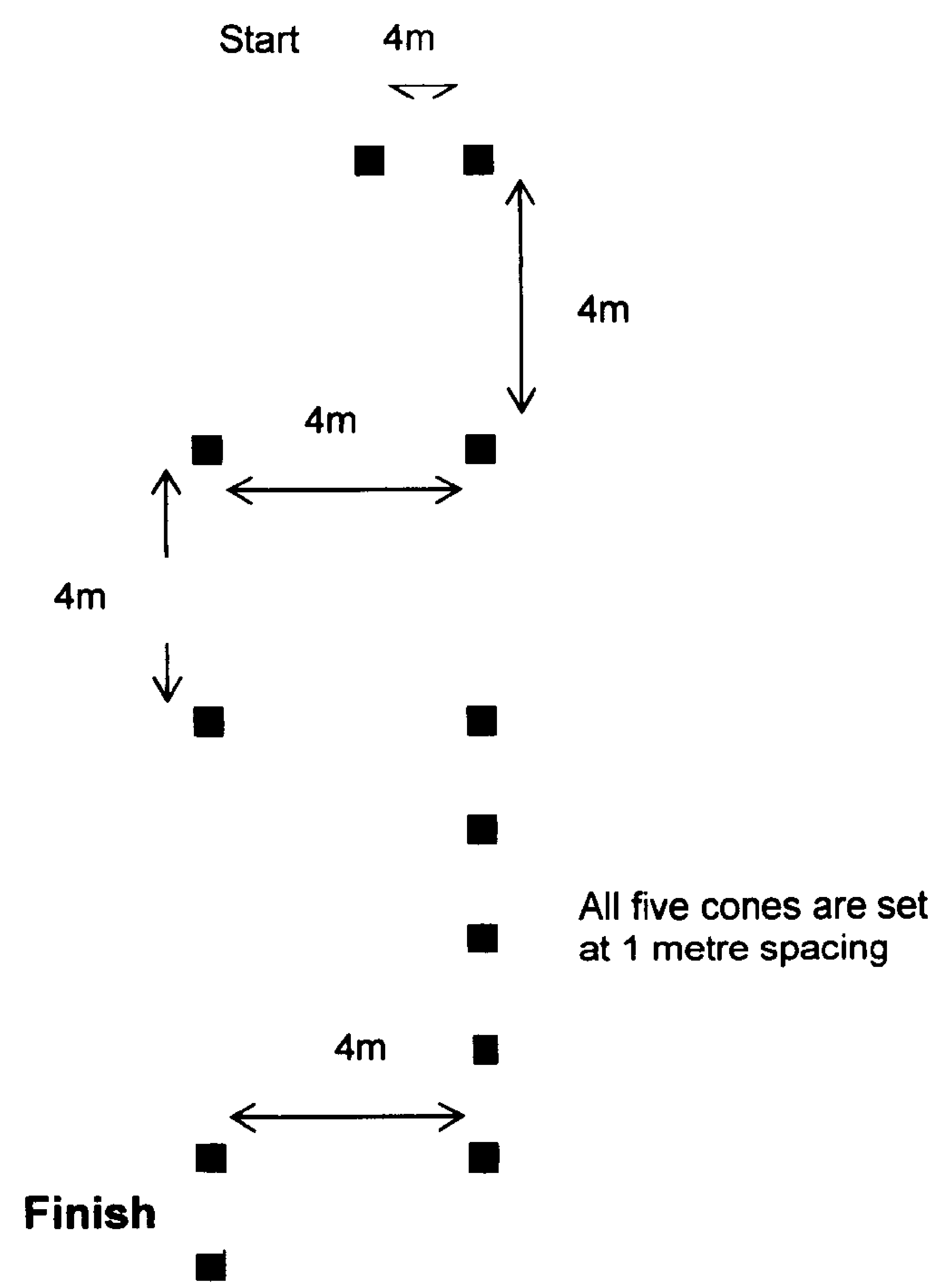

Figure 6.1: Diagram showing the agility test plan

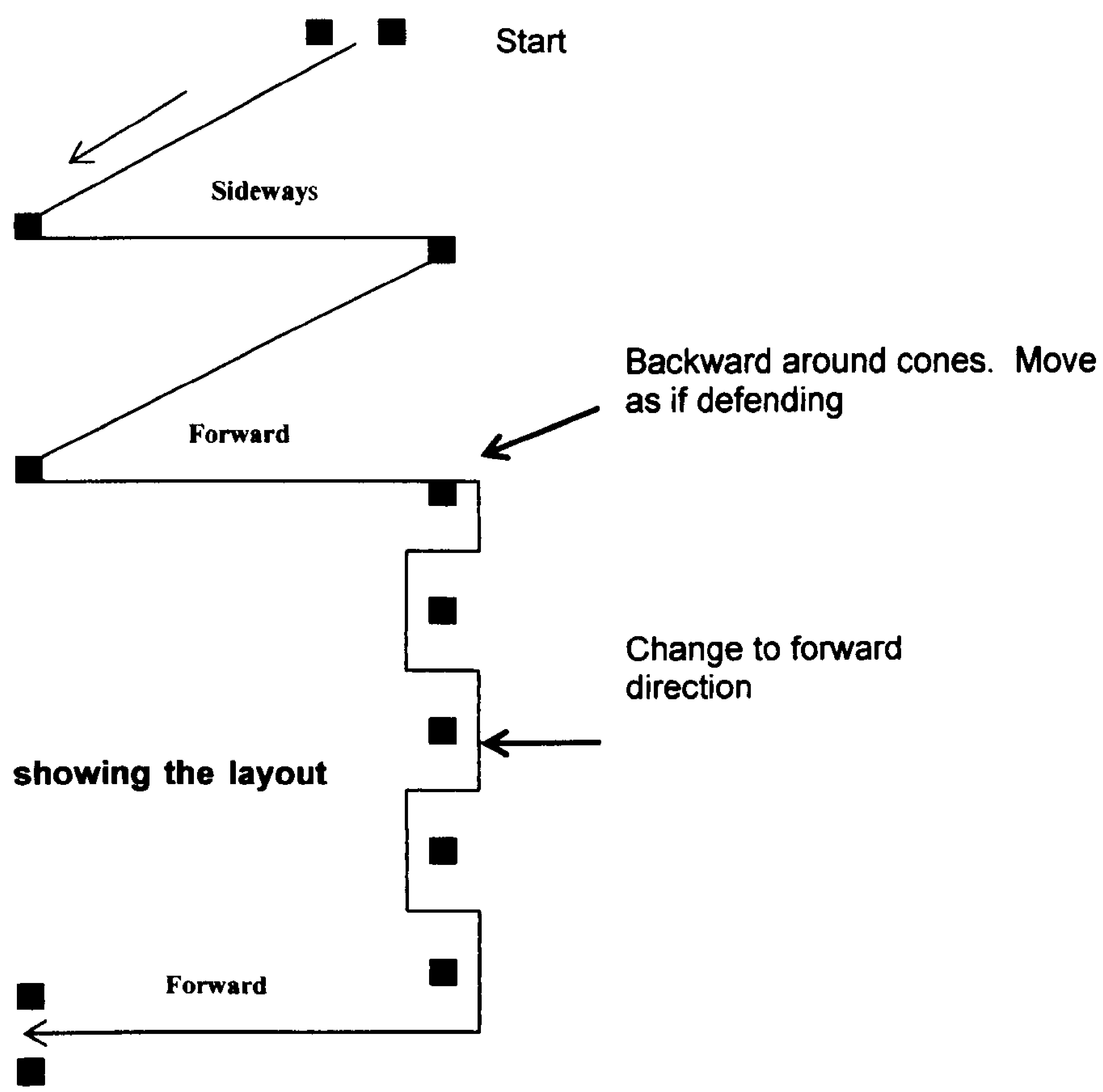

Figure 6.2: Diagram showing the layout for the agility test.

6.3.2 10 Metre Sprint

The sprint performance was measured over 10-metres (m), with the subjects using a standing start. The running time was recorded with photoelectric cells, using the Newtest Power System (2000 Newtest Oy – Finland).

6.3.3 Hamstring and Trunk Flexibility

Hamstring and trunk flexibility was measured using the YMCA Trunk Flexion Test (Golding *et al.*, 1989). The sit and reach box (Fitech: UK) was placed, on the floor, against the wall and the subjects were asked to remove their shoes and stockings.

The subjects were then asked to sit on the floor with their knees together and feet flat against the sit and reach box approximately 15-30 centimetres apart. As the investigator held their knees flat on the floor the subject reached forwards, with their arms fully extended. Subjects were asked not to "jab" but to push smoothly during the movement. The distance, in centimetres, reached was then read using the scale marked on the box. The test was repeated three times, and the value for the furthest reach is taken as the measure of flexibility.

6.3.4 Multistage Shuttle Run (MSR)

Aerobic fitness was calculated using performance on the Multistage Fitness Test (Ramsbottom *et al,* 1988). Subjects were required to run for as long as possible, until they could no longer keep up with the speed set by the audio-timer. At this point they were withdrawn from the test. The validity and reliability of this test with children has been previously demonstrated by Hemmings *et al.*, (2003) A twenty metre testing area was marked using a tape measure and cones and subjects had to ensure one foot was placed, either on or behind the 20-metre mark at the end of each shuttle. If the individual arrived on the mark before the beep sounds, they were instructed to turn around and wait for the next beep, then resume running and adjust their speed. At the end of each test the level and numbers of shuttles achieved on that level were recorded.

The subjects were required to wear Polar Vantage NV Heart Rate monitors during the tests (Polar, Finland), with a heart rate of 200bpm being accepted as an indication of maximal effort (Armstrong and Welsman, 1997). Specific MSR performances were excluded from the final analysis if the subject's heart rate failed to reach 200bpm indicating maximal effort having been attained.

Each group of children was provided with the opportunity to practice the MSR during the closed season prior to the testing period. During the early stages of the test a coach acted as a "pacer", and ran along side the subjects allowing them to adjust to the desired pace.

6.3.5 Data Handling – Physiology Section.

The Kolomogorov-Smirnov test was used to investigate the distribution of the both the baseline data values and the individual linear regression co-efficient values.

Baseline measurements from both seasons one and two were subjected to independent t-tests or Mann-Whitney test to determine if there was any significant difference between the same age groups across the two seasons.

When selecting the method of statistical analyses to examine the rate of change in the selected physiological parameters there are a number of considerations that have to be taken into account: when carrying out a repeated measures design subjects may fail to attend testing sessions. Secondly the chosen method must also ensure that changes in physical fitness as a result of growth and maturation are not mistakenly accepted as being due to any intervention (Welsman *et al.*, 1996; Welsman and Armstrong, 2000). Therefore in this study it was decided to use a combination of statistical techniques in order to assess change across a complete season.

Pearson's correlation coefficients were calculated to assess the association between the anthropometric and physical fitness parameters. This was done in order to detect any relationship between changes in growth and maturation with the changes in physical fitness.

For each measured parameter a regression line, $Y_{ik} = a_i + b_i{}^* t_k$, was calculated for each individual to estimate the changes made over each season. Y_{ik} is the value of the measured parameter for the i^{th} individual taken at time t_k and the coefficient b_i is the estimated change in the measured parameter in an unit change in time for the i^{th} individual over the season. This coefficient is the slope of the line (Altman 1991) and is called the linear regression coefficient (LRC). The coefficient a_i is an estimate of the individual's initial value for the measured parameter at time t=0.

This method also overcame the problems outlined previously with missing values (Altman, 1991) as the regression line can be still be fitted. The coefficients are estimated for each individual by the method of Least Squares (Altman 1991), using the following formula:

$$b_i = \frac{\sum_k (y_{ik} - \bar{y}_i)(t_k - \bar{t})}{\sum_k (t_k - \bar{t})^2}$$

and

$$a_i = \bar{y}_i - b\bar{t}$$

An example LRC calculated for the height of a player in the under 11 age group using the above formulae to illustrate the interpretation of the coefficients is given in Fig 6.3.

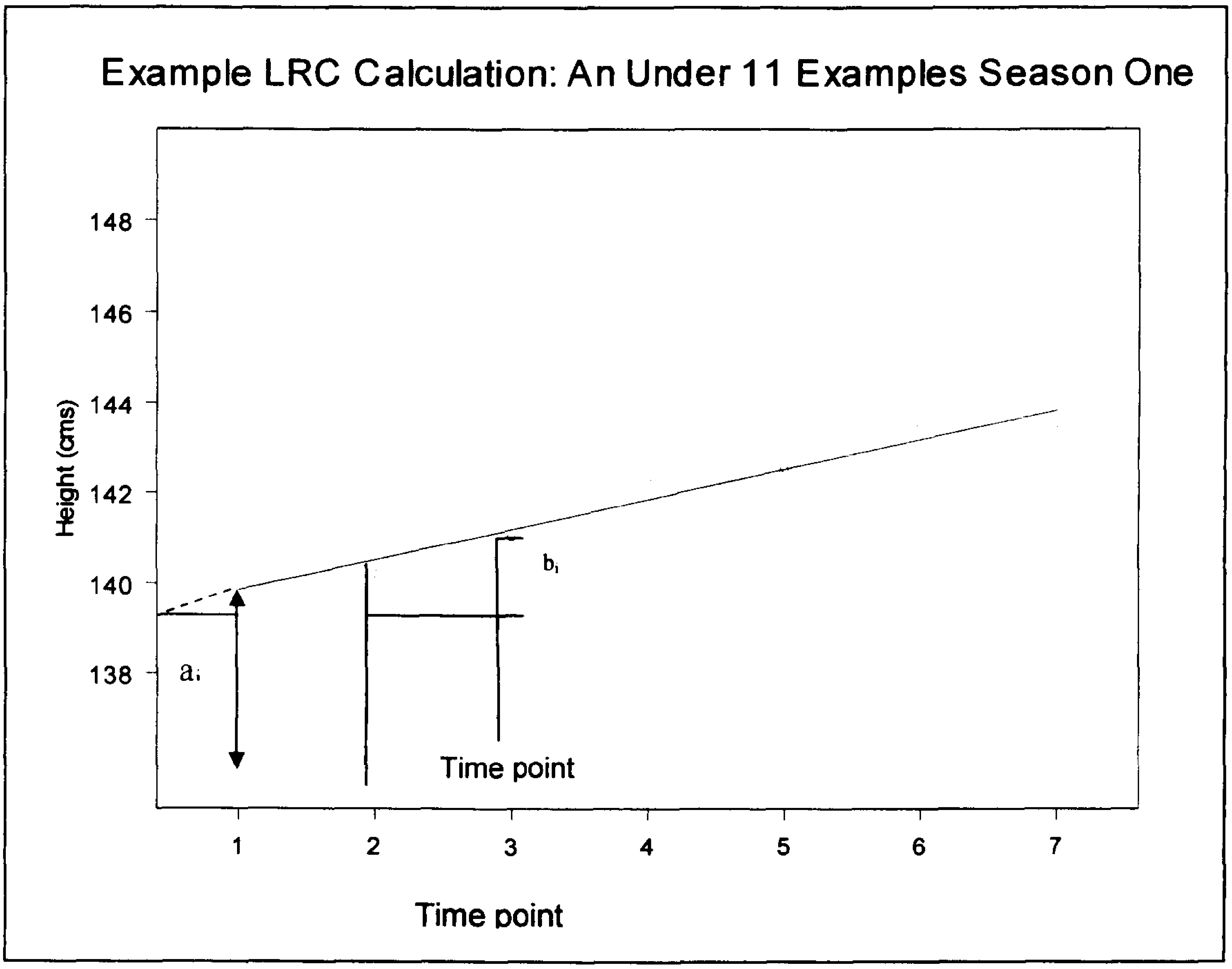

Fig 6.3: Example LRC Calculation

The individual LRC values were divided by 6 and 8 respectively in order to give a value of change per week. To test whether the mean change in a measured parameter is significantly different from zero a two-sided one sample t-test was performed on the LRCs for each individual in each group.

The use of this combination of techniques ensures that changes due to growth and maturation are observed. The possible errors inherent in the adjustment of observed values are also avoided by comparing the rates of change across each season instead of comparing the absolute or adjusted values for each of the tested parameters.

The results from these tests on the fitness parameter performance were classified as being an improvement in performance, a decrease in performance (both accepted with $p < 0.05$) or no significant change in performance ($p > 0.05$). A significant change in performance was accepted when $p < 0.05$. Improvement in MSR performance and hamstring and trunk flexibility is indicated by a positive mean LRC. Whereas an improvement in 10 metre sprint time and agility run performance involve a decrease in the time taken to complete the runs and are therefore indicated by a negative mean LRC.

Paired t-tests were used to test whether the rate of change was different between the same age groups across the two seasons.

6.4 Psychological Measurements

6.4.1 Mood states

Pre-training mood states were measured using the 24 item Brunel University Mood Scale (BRUMS), previously named the Profile of Mood States – Adolescents (POMS-A) (Terry *et al.*, 1999)

The inventory consists of six mood constructs of Anger, Confusion, Depression, Fatigue, Tension and Vigour. Scale scores are expressed as T scores taken from normative data for "right now" responses to the BRUMS from athletes before competition (Lane and Terry, 1999). The Brunel University Mood Scale was chosen as the measure of mood because of its brevity and the scale has been validated with adolescents as young as 11 years of age (Terry *et al.*, 1999).

6.4.2 Brunel Mood Scale (BRUMS)

Subjects were asked to rate "*How are you feeling right now*" in terms of the 24 mood descriptors e.g. "Worried", "Unhappy" etc. Responses were given on a 5-point scale where 0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, and 4 = extremely.

Each of the mood descriptors were factored into the six subcomponents of the mood construct: Anger, Confusion, Depression, Fatigue, Tension, and Vigour. This was achieved by adding each of the scores given for each of the four mood descriptors included in each mood construct (Table 6.2).

Table 6.2: Composition of the six subcomponents of the mood construct

Subcomponent	Individual Mood States
Tension	Anxious, nervous, panicky, worried
Depression	Depressed, downhearted, miserable, unhappy
Anger	Angry, annoyed, bad-tempered, bitter
Vigour	Active, alert, energetic, lively
Fatigue	Exhausted, sleepy, tired, worn-out
Confusion	Confused, mixed up, muddled, uncertain

The total mood disturbance (TMD) was calculated using the following formula:

$$TMD = (anger + confusion + depression + fatigue + tension - vigour) + 100$$

Written instructions were provided to the subjects to ensure consistency during data collection.

Subjects were asked to complete the questionnaire prior to the practice session immediately following the fitness testing sessions and to post the completed questionnaires using a FREEPOST envelope provided.

6.4.3 BRUMS - Data Handling

The 24 items were factored into the six factors of the mood construct. Paired t-tests were then used to investigate the differences between week 0 and week 42 of both seasons one and two of the study, for both the individual mood construct scores and the TMD. Statistical significance was set a $p < 0.05$.

6.4.4 Life Demands

The sources and symptoms of life stresses that may be affecting the mood profile of the subjects was measured using a modified version of the Daily Analyses of Life Demands for Athletes (DALDA) (Ryder *et al.*, 2001). The modified format consists of the original nine "sources of stress" and 25 "Symptoms of Stress", but structured with a clearer definition and response for a UK sample.

A readability study was carried out on the modified DALDA, and it demonstrated that the modified DALDA was significantly easier to understand than the original but elicits the same response from children aged 11 and older (Ryder *et al.*, 2001) (see appendix B for details of the readability study).

6.4.5 DALDA Procedures

The DALDA questionnaire was also used as a measure of "here and now feelings". Subjects were asked to indicate "*How you are feeling right now*" in terms of 9 sources of stress and 25 symptoms of stress, on a three point check list representing "a" – worse than normal, "b" – normal, and "c" – better than normal (Ryder *et al.*, 2001). The number of answers given as "a" were totalled for both section a: sources of stress and section b: symptoms of stress. The overall total of "a" answers was also calculated. The players completed the tests during a familiarisation study prior to the season starting to ensure the subjects understood the questionnaires and the meaning of each adjective. During the trial run, the experimenter was present to provide clarification if required.

Prior to completing the questionnaires, subjects were instructed that the forms should be completed individually and to refrain from talking about what they had selected to avoid undue influence. It was also stressed that whole interest should be focused on the players' personal feelings.

6.4.6 DALDA - Data handling

The percentage of the total responses given as "worse than normal" ("a"), by individuals, was calculated for sections (a) and (b).

A log transformation Log ((a +0.5)/(100 – a+0.5)) was used in order to normalise the data on the calculated percentages. Where a = the percentage of the total responses given as worse than normal.

Mann-Whitney tests were then used to investigate the differences between week 0 and week 42 of both seasons one and two of the study, for sections (a) and (b) as well as the total number of "a" answers given. Statistical significance was set a $p < 0.05$.

6.5 General Immunological Methods

6.5.1Saliva Samples:

Prior to sampling subjects were required to rinse their mouths with water. Subjects were then required to sit with their heads forward and to collect saliva in their mouths. They were told not to swallow for two minutes. This saliva was then discarded. Following this subjects were required to sit with their heads forward and to collect saliva in their mouths. They were told not to swallow, for 4 minutes. The saliva was then dribbled in to a collecting tube and frozen at -18°C until the analysis was carried out.

6.5.2 Aliquoting

All samples were defrosted at room temperature and a 1 ml sample was pipetted into a 1.5 ml microcentrifuge tube (Costar, England). The saliva sample was then centrifuged (Micro-centrifuge, Hawksley, England) at 2000g for five minutes. The supernatant was pipetted into four, 200µl samples and stored frozen at -18°C.

6.6 Salivary IgA Analysis

6.6.1 Measuring IgA

Ig's and antibodies can be quantified by a variety of methods, in both serum and saliva. A Sandwich Enzyme Linked Immunoassay (ELISA) is commonly used to measure salivary IgA (Crowther, 1995; Mackinnon, 1999).

A sandwich ELISA has been validated for IgA. When applied to the ELISA diluted human saliva showed parallelism with the standard curve. Intra and inter assay variation was determined and shown to be 6.17% (n=4) and 7.49% (n=4) respectively. The IgA ELISA was able to recover 104+/-7.0% (n=4) of a 0.1mg spike added to 1ml of saliva before dilution (Costa *et al.*, Unpublished).

6.6.2 Preparation – 24 hours prior to analysis

Anti-human IgA antibody raised in rabbit (Sigma) was diluted to a 1/5000 dilution with PBS (NaCl 8g, KCl 0.2g, KH_2PO_4 0.249g, Na_2HPO_4 1.44g per l^{-1}). Immulon 1 ELISA plates (Thermo Labsystems, England) were then coated with 50 µl of this solution. The ELISA plates were covered and stored overnight at 4°C.

6.6.3 Preparation – Day of analysis

Human IgA (Sigma) was diluted in ELISA Buffer (PBS and 0.001% Tween) to form a standard curve utilising a serial dilution from 17.9 $ng.ml^{-1}$ to 9200 $ng.ml^{-1}$. The previously obtained supernatant, taken from saliva, was diluted into an appropriate dilution that gave an absorbance on the discriminating part of the curve (typically 1/8) with ELISA Buffer.

6.6.4 ELISA Method

The anti-human solution was removed from the plate and the plate tapped dry. A 3% dried non fat milk solution was made with PBS and 200 µl was pipetted into each well (Finiipipette, Thermo Labsystems, England). The plate was covered and incubated at room temperature for 1 hour and then washed 3 times with wash buffer and tapped dry. 50 µl of the standards, or samples were added to the appropriate wells, the plate was covered and incubated at 37°C for 1 hour. The plates were then gently tapped to ensure efficient mixing.

Following the incubation period the plates were washed 3 times and tapped dry and 50 µl of the peroxidase solution was pipetted into each of the wells. (Prior to the completion of the incubation period a 1/5000 dilution of peroxidase labelled anti human IgA (Sigma), raised in goat, was made using ELISA buffer containing 3% dried non fat milk).

The plates were covered and incubated at 25°C for a further hour. Following the incubation period the plates were washed 3 times and tapped dry, 50 μl of the substrate solution (substrate buffer and chromogen) was pipetted into each of the wells. The plates were then incubated at 25°C, in the dark, for 10 minutes.

Following the incubation period 25 μl of 1M phosphoric acid (Fisher, England) was pipetted into each well and the plate was read at 450 nm using a MRX II (Dynex Technologies, UK)

6.7 Salivary Cortisol Analysis

Salivary cortisol has been reported as a valid and reliable measure of plasma levels (Kugler *et al.*, 1996; Perna *et al.*, 1997; Perna *et al.*, 1998; Schubert *et al.*, 2003; Vedhara *et al.*, 2003). Saliva collection also reduces the "stress" of sampling that results from venepuncture, which in turn can increase cortisol secretions (Riad-Fahmy *et al.*, 1982)

An indirect competitive ELISA has been validated with the cortisol ELISA showing that when applied to the ELISA diluted human saliva showed parallelism with the standard curve. Intra and inter assay variation was determined and shown to have coefficients of variation of 3.44% (n=5) and 11.16% (n=5) respectively. The cortisol ELISA was able to recover 115+/- 14.3% (n=4) of 10ng spike to 1ml of undiluted saliva (Costa *et al.*, Unpublished).

6.7.1 Plate Preparation

Immulon 4 ELISA plates (Thermo Labsystems, England) were coated using anti-cortisol antibody (1/33750 dilution in carbonate buffer from 1/50 stock) (Dr Corelie Monroe, Vancouver, USA). Then 100 μl of carbonate buffer was pipetted into the inside wells of the ELISA plate (Finiipipette, Thermo Labsystems, England) and 100μl of carbonate buffer was pipetted into the outside wells. The plate was then covered and stored for 12 hours at 4°C.

6.7.2 Preparation – Day of analysis

Cortisol-HRP (Dr Corelie Monroe, Vancouver, USA) was diluted using EIA-PBS (50mM NaCl, KCl, KH_2PO_4, $NaHPO_4$ (Sigma, UK)) using a 1 in 60,000 dilution.

The previously obtained supernatant, taken from saliva, was diluted into an appropriate dilution to bring in the calibration range of the ELISA (typically between 1/4 and 1/8 for saliva) using distilled water.

6.7.3 ELISA Method

An automated plate washer (Ultrawash Plus (Dynex Technologies, UK)) was used to wash the coated ELISA plates. The wells were washed, 3 times, with 250µl wash buffer (PBS + 0.05% TWEEN 20) and tapped dry. 50 µl of EIA PBS was then added to all wells, followed by 50 µl standards, samples or controls which were added in triplicate to the appropriate wells. Following this 50 µl Cortisol HRP was added to all wells, except the substrate control. After the application of each reagent the wells were gently tapped to ensure efficient mixing. Subsequently the plates were left to incubate at 25°C for 90 minutes.

Prior to the completion of the incubation period the substrate solution was prepared using a 1:10 ratio of Veterquinol TMB chromogen tp substrate buffer (Biovet, Canada). Following the incubation period the ELISA plates were washed 3 times and tapped dry, then 100 µl of substrate solution was added to all wells and the plates were incubated, again at room temperature, in the dark for 1 hour.

Following the incubation period 50 µl of 1M phosphoric acid (Fisher, England) was added to all the ELISA plate wells. The ELISA plate was then read at 450 nm using the MRX II (Dynex Technologies, UK).

6.8 Osmolality

In the exercise immunology literature both salivary IgA and cortisol levels have been expressed in a number of ways. Some papers cite the absolute concentrations, however it is possible when citing absolute concentration that the value could be artificially increased by the subject suffering from dehydration and the drying effects of oral breathing (Blannin *et al.*, 1998; Mackinnon, 1999; Walsh *et al.*, 1999). For example if the IgA secretion rate remained constant but the subject's saliva flow rate decreased (due to dehydration) then the concentration of IgA would appear artificially high (Mackinnon, 1999).

Recently it has been suggested that presenting the IgA and cortisol concentrations relative to osmolality overcomes the limitations of both the absolute IgA values and those presented relative to total protein (Blannin *et al.*, 1998; Walsh *et al.*, 1999). Osmolality is a measure of the total dissolved solute concentration (Blannin *et al.*, 1998). Saliva protein contributes less than 1% to the osmolality value increases in IgA and cortisol values will not affect changes in the osmolality value, as such osmolality is considered a valid representation of the subjects hydration. The validity of presenting salivary IgA and cortisol data relative to osmolality in order to adjust the figure to account for changes in hydration status, has been previously demonstrated (Blannin *et al.,* 1998).

Osmolality was measured using a digital micro-osmometer (Roebling, Berlin, Germany). The osmometer was calibrated using a 100 µl aliquot of distilled water, and then individual samples analysed

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Chapter 7: Physiology

7.1 Introduction

The review of literature for this study is situated in section 2.1 of this thesis.

Aims and Objectives

The aim of this study was to investigate the effect of restricting the number of matches played over a season on the physical fitness of young soccer players as indicated by their performance in a battery of field tests.

7.2 Methodology

The details of the physiological methodology adopted are outlined in section 6. of this thesis.

Details of the subject numbers are presented in Table 7.1.

Table 7.1: Subject numbers in the physiological study

Age Group	Season One	Season Two
Under 11	12	14
Under 12	14	14
Under 13	16	16
Under 14	15	14
Under 15	24	24

7.3 Results Section

Baseline Data

The baseline data for each of the individual studies is presented in Table 7.2 and examines the between season differences for each of the age groups observed. The only significance differences were in: the U12s with the subjects tested in season two being more flexible, quicker over 10-metres, and more agile than the subjects observed in S1. In the U13s the subjects observed in S1 were significantly taller and heavier than those observed in S2 and in the U14s the values obtained for ectomorphy were significantly higher in S1 than in S2. There were no other significant differences.

Table 7.2: Baseline Data from individual age groups, for Season One (S1) and Season Two (S2). * Denotes significance accepted at $p<0.05$

Parameter	U11 S1	U11 S2	U12 S1	U12 S2	U13 S1	U13 S2	U14 S1	U14 S2	U15 S1	U15 S2
Height (cm)	138.9 (3.16)	134.9 (3.81)	146.3 (5.53)	143.6 (5.25)	**156.0*** **(7.48)**	**148.1*** **(6.32)**	157.9 (9.46)	158.0 (3.95)	167.3 (6.00)	165.4 (10.00)
Weight (kg)	31.3 (3.06)	29.5 (3.82)	35.6 (4.41)	35.8 (5.15)	**45.1*** **(5.73)**	**40.8*** **(4.93)**	47.7 (9.00)	52.6 (7.73)	63.8 (14.19)	56.9 (11.79)
Endomorphy	2.41 (0.49)	2.44 (0.30)	2.35 (0.59)	2.86 (0.89)	2.77 (0.51)	3.00 (0.95)	2.46 (0.63)	2.50 (0.91)	3.00 (0.46)	3.02 (1.02)
Mesomorphy	4.91 (0.66)	4.38 (0.54)	3.80 (0.83)	3.22 (0.82)	2.86 (0.89)	2.65 (0.68)	4.64 (1.42)	4.62 (1.03)	2.00 (0.46)	2.25 (0.49)
Ectomorphy	4.25 (1.08)	3.44 (1.28)	3.61 (0.96)	3.40 (1.15)	4.5 (0.83)	4.69 (0.90)	**3.50*** **(0.62)**	**2.50*** **(0.91)**	4.06 (0.67)	4.69 (0.97)
Somatotype Characterisation	Mesomorph -ectomorph	Ectomorph-mesomorph	Mesomorph-ectomorph	Mesomorph-ectomorph	Balanced ectomorphy	Balaanced ectomorph	Mesomorph-ectomorph	Balanced mesomorph	Ectomorph-mesomorph	Ectomorph
Ham&Trunk (cm)	32.1 (5.59)	35.9 (3.53)	**31.8*** **(4.02)**	**37.9*** **(4.12)**	10.25 (0.64)	9.65 (1.45)	34.3 (5.38)	38.5 (3.31)	12.20 (1.07)	12.11 (1.17)
MSR (beep/level)	8.24 (2.51)	9.25 (0.44)	9.28 (1.10)	9.79 (1.04)	10.58 (0.38)	10.44 (0.49)	10.80 (1.47)	11.29 (1.22)	9.29 (0.99)	9.46 (2.01)
10 Metre Sprint (sec)	2.05 (0.12)	2.04 (0.06)	**2.02*** **(0.15)**	**1.93*** **(0.08)**	32.3 (6.43)	32.4 (9.89)	1.87 (0.07)	1.79 (0.06)	35.9 (6.01)	40.3 (5.09)
Agility time (secs)	10.84 (0.91)	11.48 (0.48)	**11.19*** **(0.73)**	**10.60*** **(0.53)**	1.93 (0.06)	2.59 (2.24)	10.95 (0.64)	10.31 (0.15)	1.77 (0.08)	1.76 (0.08)

Under 11 Results

The mean LRC values for the anthropometric data, collected in the under 11s age group are presented in Figure 7.1.

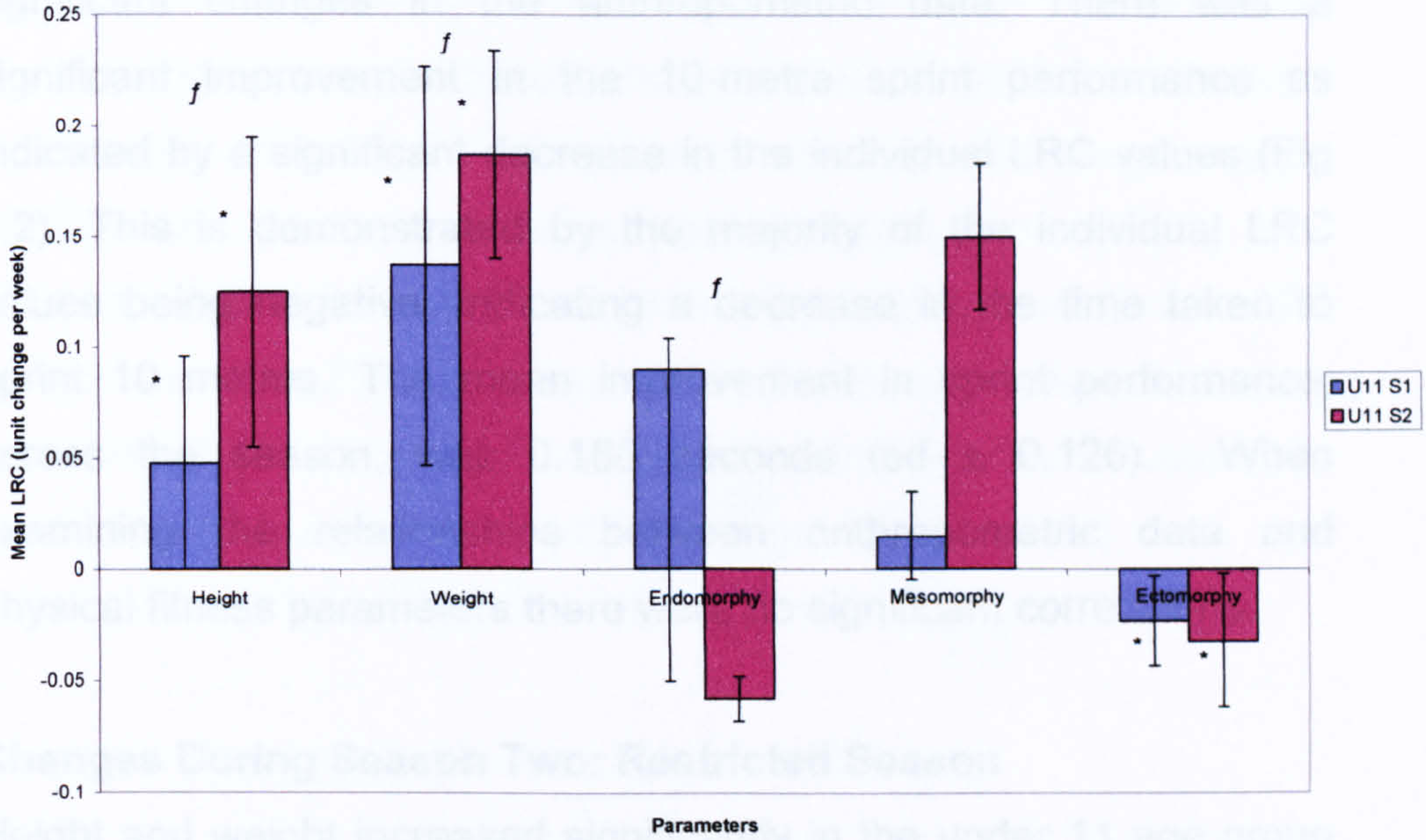

Fig 7.1: Mean LRC values: Under 11s, anthropometric data[1]

The mean LRC values for the fitness parameter data, collected in the under 11s age group are presented in Figure 7.2.

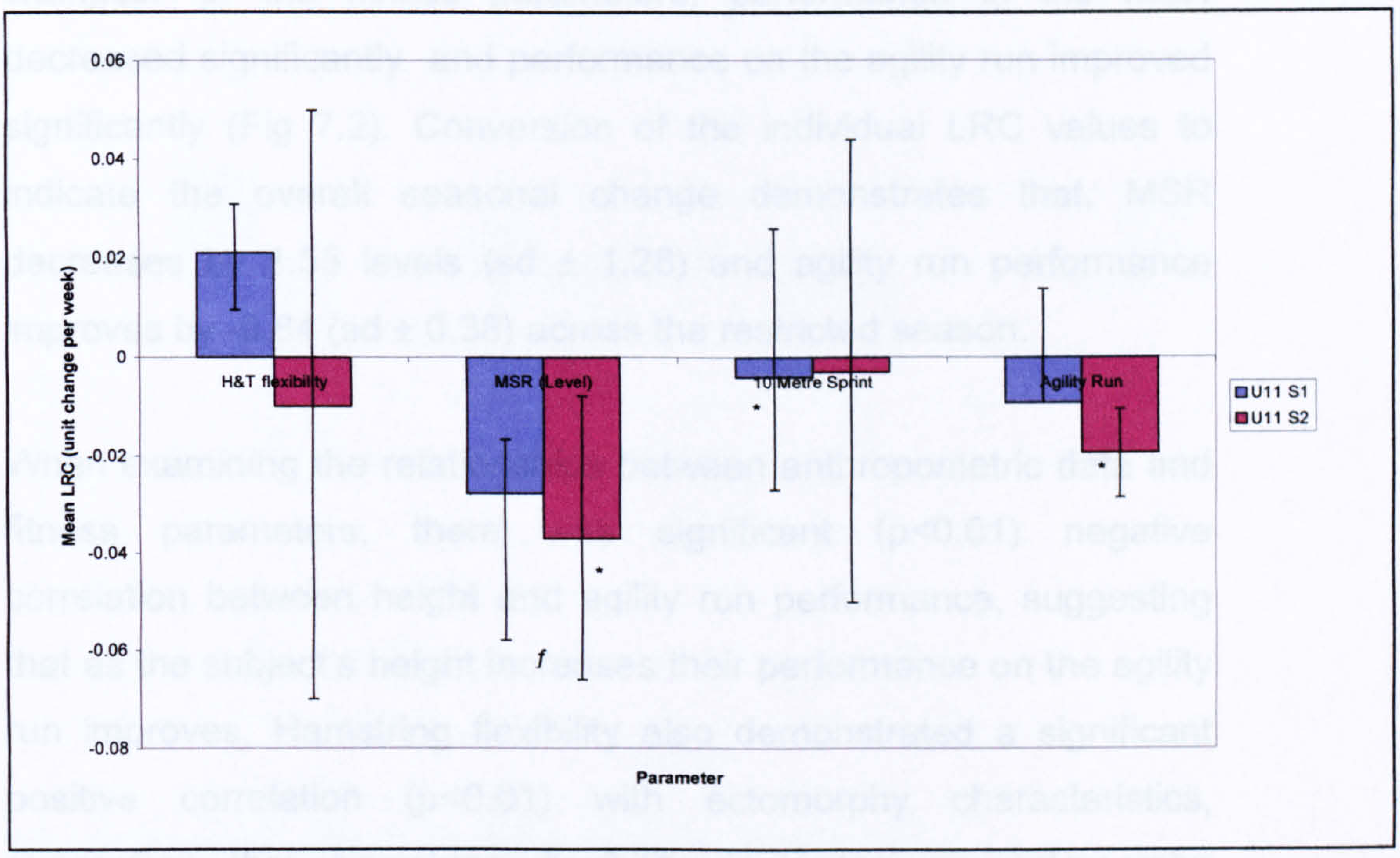

Fig 7.2: Mean LRC values: Under 11s, fitness parameter data[1]

* denotes a significant change within the season. *f* denotes a significant difference between the seasons. Significance was accepted at $p<0.05$

Changes During Season One: Unrestricted Season

The under 11's age group in season one showed a significant increase in height, weight and ectomorphy (Fig 7.1) with no other significant changes in the anthropometric data. There was a significant improvement in the 10-metre sprint performance as indicated by a significant decrease in the individual LRC values (Fig 7.2). This is demonstrated by the majority of the individual LRC values being negative, indicating a decrease in the time taken to sprint 10 metres. The mean improvement in sprint performance, across the season, was 0.168 seconds (sd ± 0.126). When examining the relationships between anthropometric data and physical fitness parameters there were no significant correlations.

Changes During Season Two: Restricted Season

Height and weight increased significantly in the under 11 age group in season two (as indicated by significant LRC values) and ectomorphy characteristics decreased significantly as indicated by significant negative LRC values (Fig 7.1), with no other significant changes. Of the fitness parameters, performance in the MSR decreased significantly and performance on the agility run improved significantly (Fig 7.2). Conversion of the individual LRC values to indicate the overall seasonal change demonstrates that, MSR decreases by 1.55 levels (sd ± 1.28) and agility run performance improves by -0.84 (sd ± 0.38) across the restricted season.

When examining the relationships between anthropometric data and fitness parameters, there was significant ($p<0.01$) negative correlation between height and agility run performance, suggesting that as the subject's height increases their performance on the agility run improves. Hamstring flexibility also demonstrated a significant positive correlation ($p<0.01$) with ectomorphy characteristics, suggesting that hamstring flexibility increases as ectomorphy characteristics increase.

Comparison between Season One and Season Two

When comparing changes in the two under 11 age groups, the mean height and weight change was greater in season two than in season one. Endomorphy characteristic demonstrated a significant difference in the rate of change, with season one demonstrating a slight increase and season two demonstrating a slight decrease (Fig 7.1). The only other significant difference between cohorts was in the MSR performance (Fig 7.2). This was due to the decrease across season two being 50% greater than the non-significant decrease demonstrated in season one (-0.028 compared with -0.37).

Under 12 Results

The mean LRC values for the anthropometric data, collected from the under 12s age group is presented in Fig 7.3.

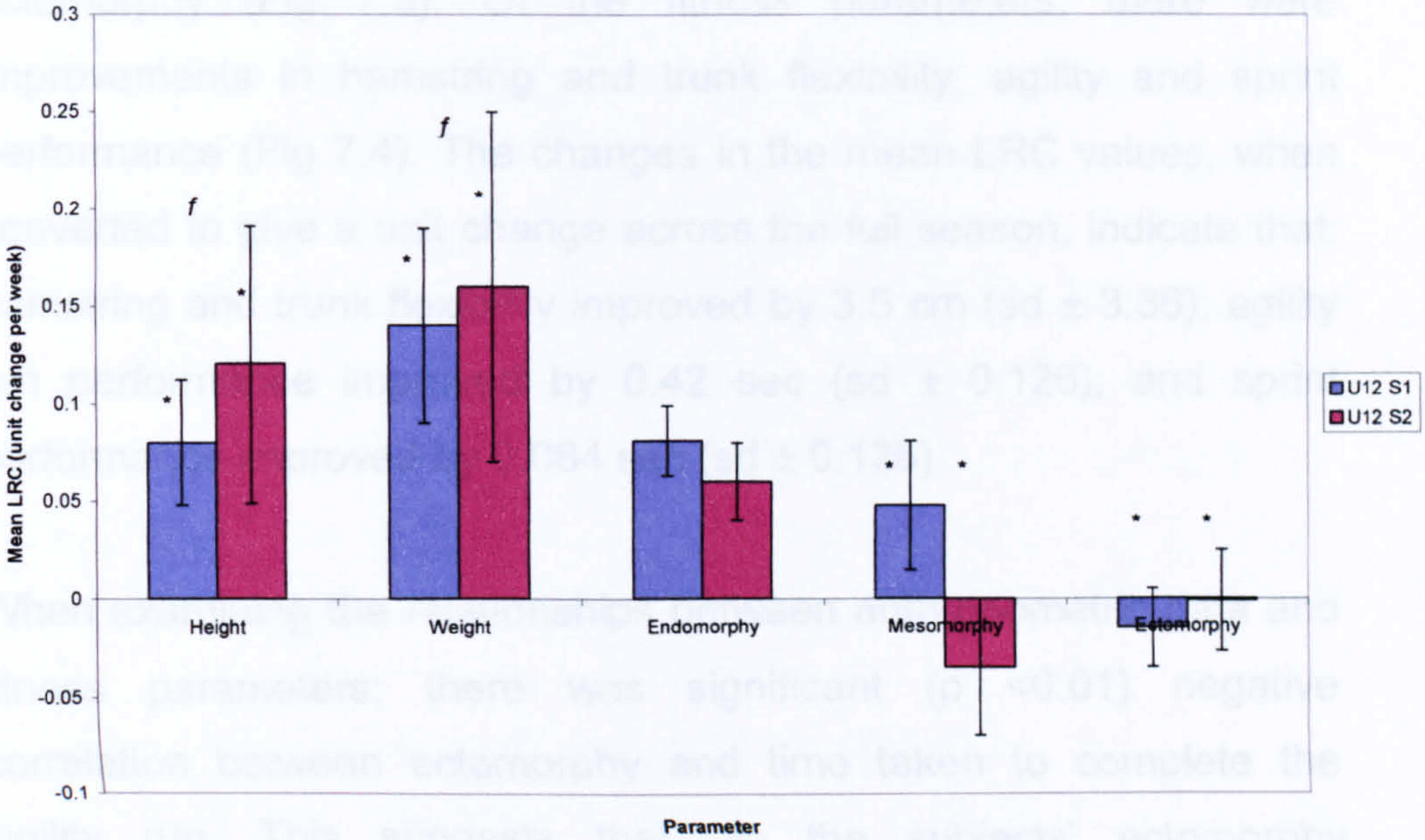

Figure 7.3: Mean LRC values: Under 12s, anthropometric data[1]

The mean LRC values for the fitness parameter data, collected in the under 11s age group is presented in Fig 7.4.

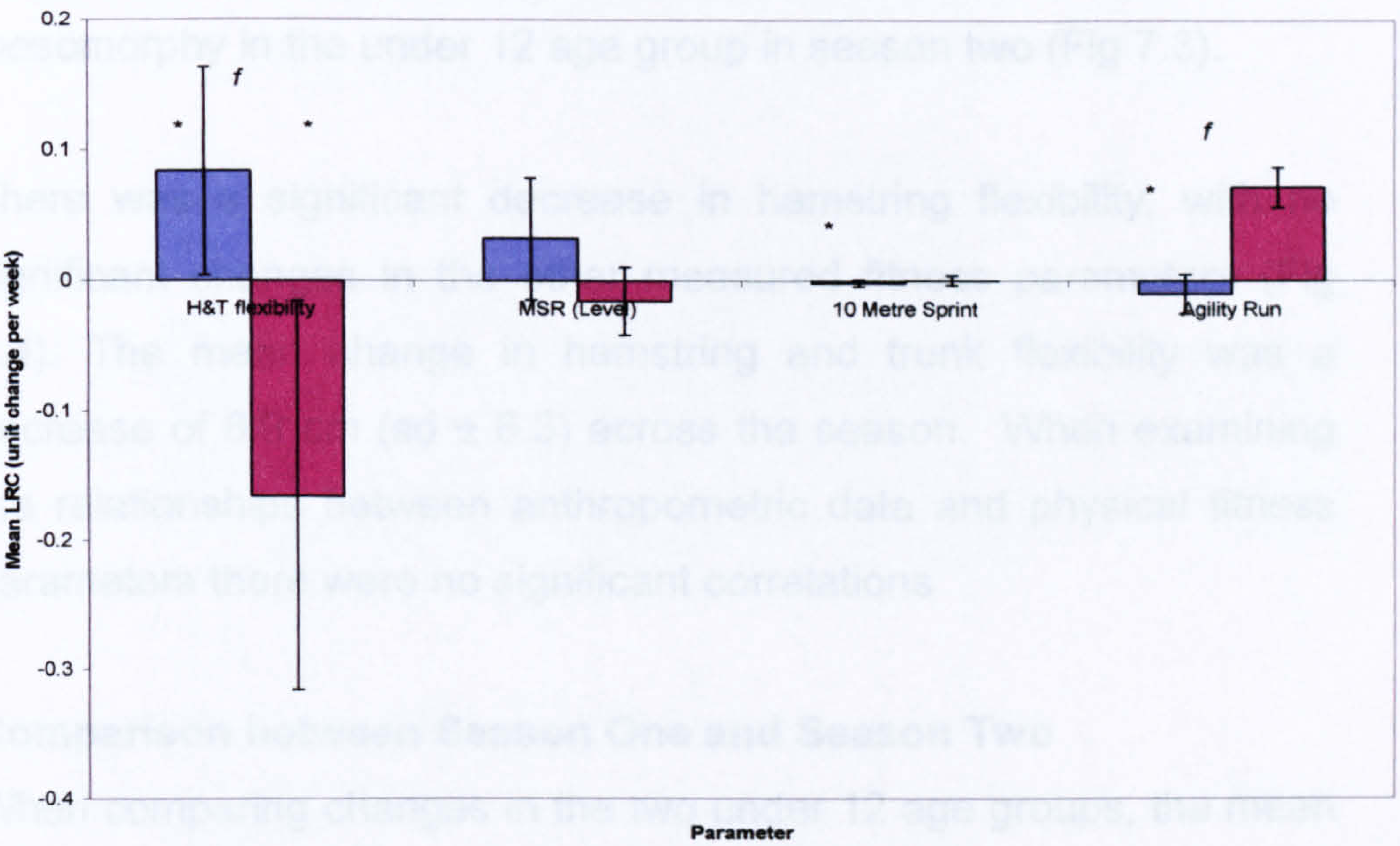

Fig 7.4: Mean LRC values: Under 12s, fitness parameter data[1]

Changes During Season One: Unrestricted Season

The under 12's in season one showed a significant increase in height, weight and mesomorphy, and a significant decrease in ectomorphy (Fig 7.3). Of the fitness parameters, there were improvements in hamstring and trunk flexibility, agility and sprint performance (Fig 7.4). The changes in the mean LRC values, when converted to give a unit change across the full season, indicate that; hamstring and trunk flexibility improved by 3.5 cm (sd ± 3.36); agility run performance improved by 0.42 sec (sd ± 0.126); and sprint performance improved by 0.084 sec (sd ± 0.126).

When examining the relationships between anthropometric data and fitness parameters; there was significant ($p < 0.01$) negative correlation between ectomorphy and time taken to complete the agility run. This suggests that, as the subjects' ectomorphy characteristics increase their agility run performance improves.

Changes During Season Two: Restricted Season

Height and weight increased, whilst there was a decrease in mesomorphy in the under 12 age group in season two (Fig 7.3).

There was a significant decrease in hamstring flexibility, with no significant changes in the other measured fitness parameters (Fig 7.4). The mean change in hamstring and trunk flexibility was a decrease of 6.9 cm (sd ± 6.3) across the season. When examining the relationships between anthropometric data and physical fitness parameters there were no significant correlations

Comparison between Season One and Season Two

When comparing changes in the two under 12 age groups, the mean change in height and weight were greater in the second season. Hamstring and trunk flexibility also demonstrated a significant difference between the two seasons with season one demonstrating a higher mean LRC value (Fig 7.4). The changes in agility run performance was also significantly different with the performance improving significantly in the first season (LRC = -0.01) and worsening over the second season (LRC = 0.072) (Fig 7.4).

Under 13 Results

The data presented in Figure 7.5 shows the mean LRC values for the anthropometric data, collected in the under 13s age group.

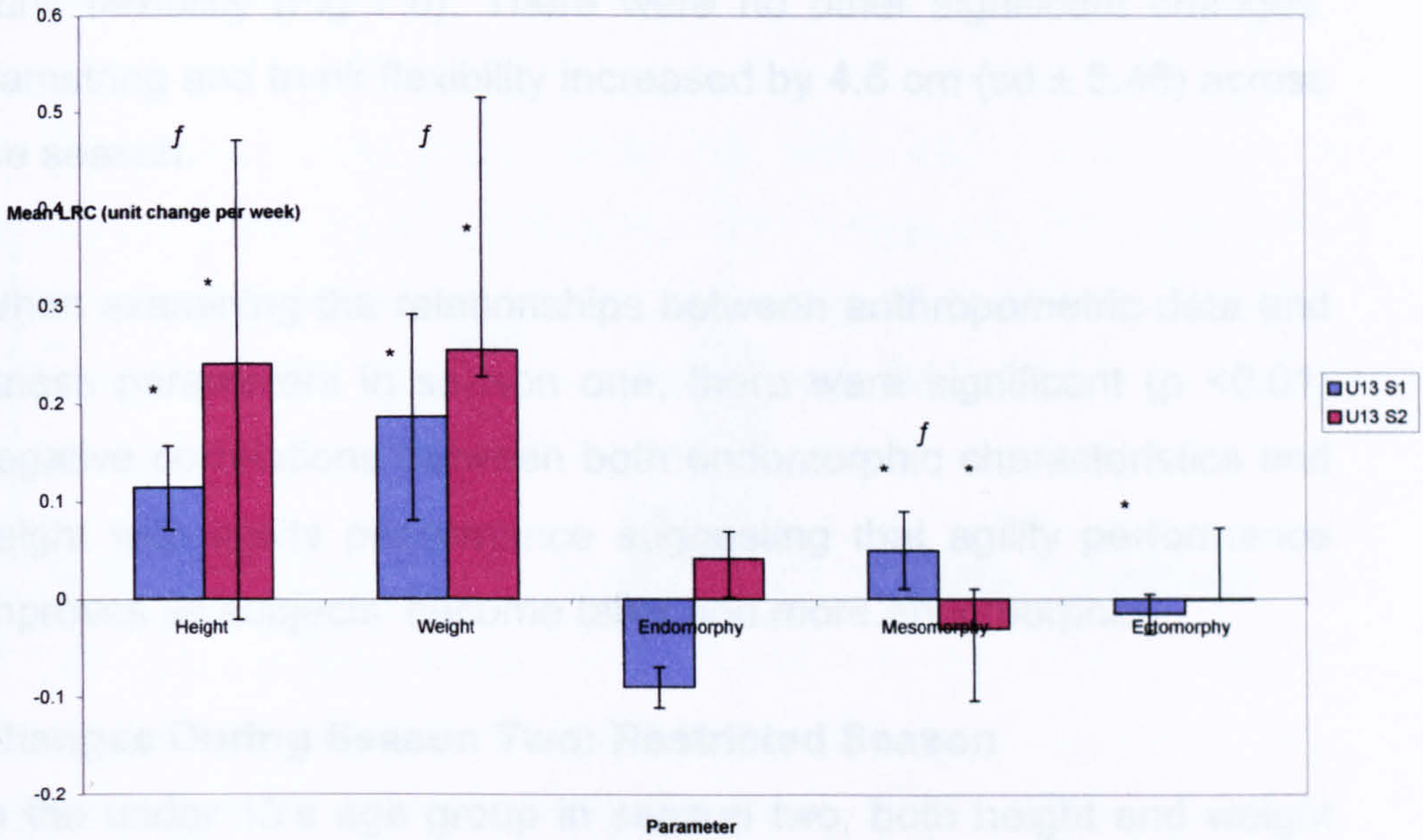

Figure 7.5: Mean LRC values: Under 13s, anthropometric data[1]

The data presented in Figure 7.6 shows the mean LRC values for the fitness parameter data, collected in the under 13s age group.

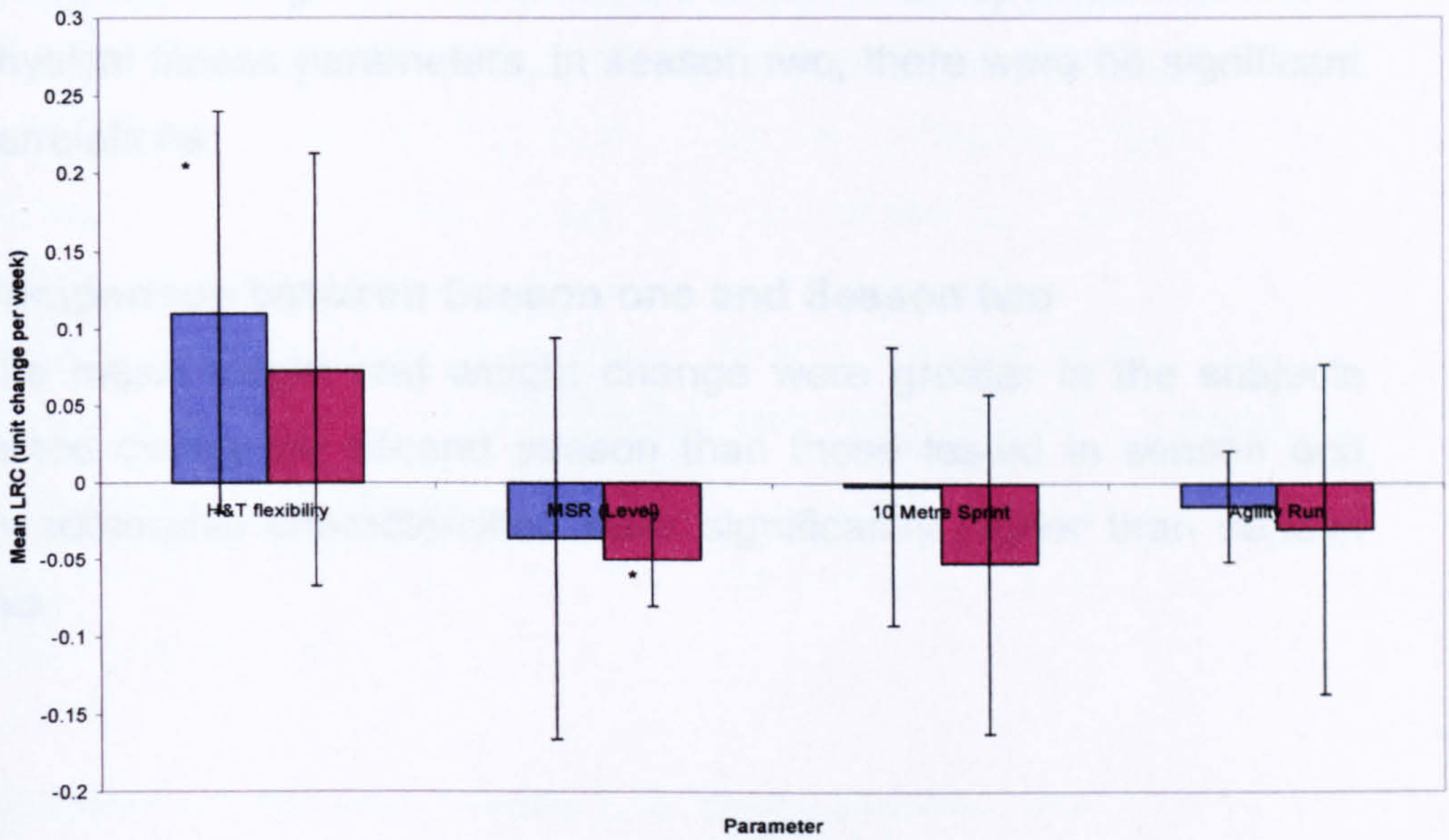

Fig 7.6: Mean LRC values: Under 13s, fitness parameter data[1]

Changes During Season One: Unrestricted Season

The under 13's age group in season one showed a significant increase in height, weight, mesomorphy (Fig 7.5), Hamstring and trunk flexibility (Fig 7.6). There were no other significant changes. Hamstring and trunk flexibility increased by 4.6 cm (sd ± 5.46) across the season.

When examining the relationships between anthropometric data and fitness parameters in season one, there were significant ($p < 0.01$) negative correlations between both endomorphic characteristics and height with agility performance suggesting that agility performance improves as subjects' become taller and more endomorphic.

Changes During Season Two: Restricted Season

In the under 13's age group in season two, both height and weight increased significantly (Fig 7.5) whilst MSR performance decreased significantly (Fig 7.6). The mean drop in MSR performance, across the season, was 2.1 levels (sd ± 1.26).

When examining the relationships between anthropometric data and physical fitness parameters, in season two, there were no significant correlations.

Comparison between Season one and Season two

The mean height and weight change were greater in the subjects tested during the second season than those tested in season one mesomorphic characteristics were significantly higher than season two.

Under 14 Results

The mean LRC values for the anthropometric data, collected in the under 11s age group are presented in Fig 7.7.

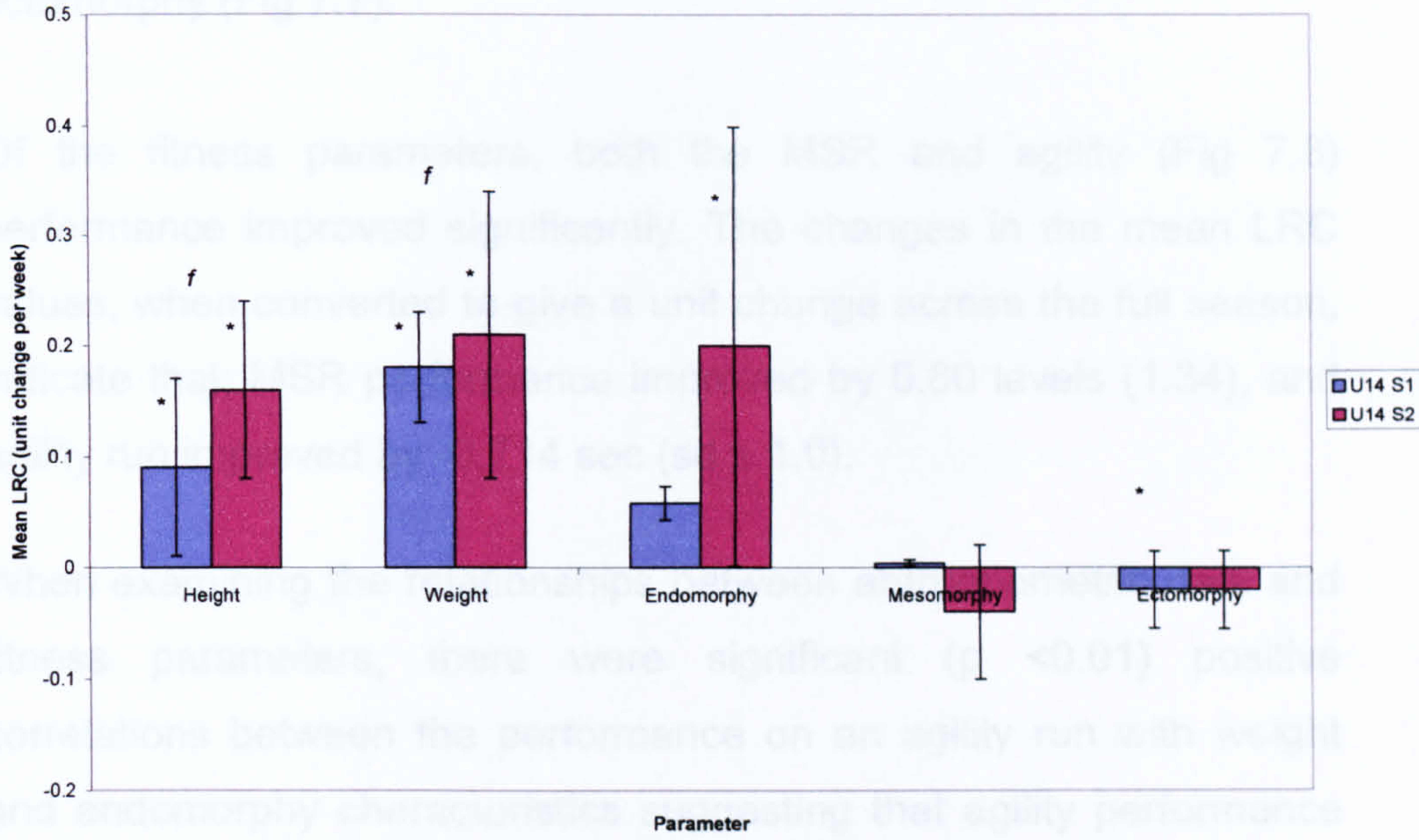

Figure 7.7: Mean LRC values: Under 14s, anthropometric data[1]

The data presented in Figure 7.8 shows the mean LRC values for the fitness parameter data, collected in the under 14s age group.

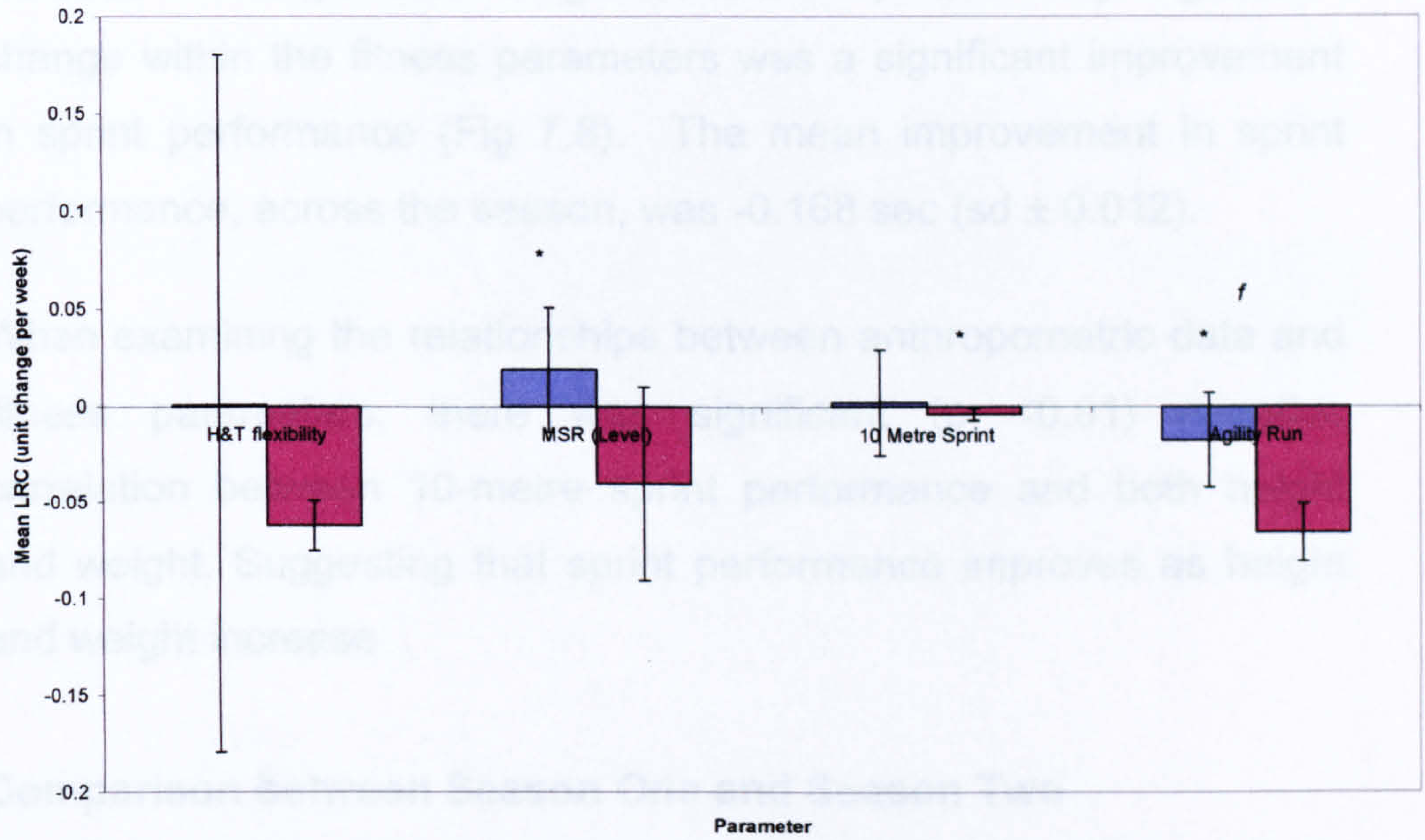

Fig 7.8: Mean LRC values: Under 14s, fitness parameter data[1]

Changes During Season One: Unrestricted Season

The under 14's age group in season one showed a significant increase in height and weight with a significant decrease in ectomorphy (Fig 7.7).

Of the fitness parameters, both the MSR and agility (Fig 7.8) performance improved significantly. The changes in the mean LRC values, when converted to give a unit change across the full season, indicate that; MSR performance improved by 0.80 levels (1.34), and agility run improved by -0.714 sec (sd ± 1.0).

When examining the relationships between anthropometric data and fitness parameters, there were significant ($p < 0.01$) positive correlations between the performance on an agility run with weight and endomorphy characteristics suggesting that agility performance decreases as both endomorphy and weight increase.

Changes During Season Two: Restricted Season

The under 14s age group in season two showed a significant increase in height and weight (Table 7.7). The only significant change within the fitness parameters was a significant improvement in sprint performance (Fig 7.8). The mean improvement in sprint performance, across the season, was -0.168 sec (sd ± 0.012).

When examining the relationships between anthropometric data and fitness parameters, there was significant ($p < 0.01$) negative correlation between 10-metre sprint performance and both height and weight. Suggesting that sprint performance improves as height and weight increase

Comparison between Season One and Season Two

The mean MSR performance change was greater in those subjects in season one than those in season two, with performance on the

MSR improving across season one and showing no significant change across season two.

Under 15 Results

The data presented in Figure 7.9 shows the group mean LRC values for the anthropometric data, collected in the under 15s age group.

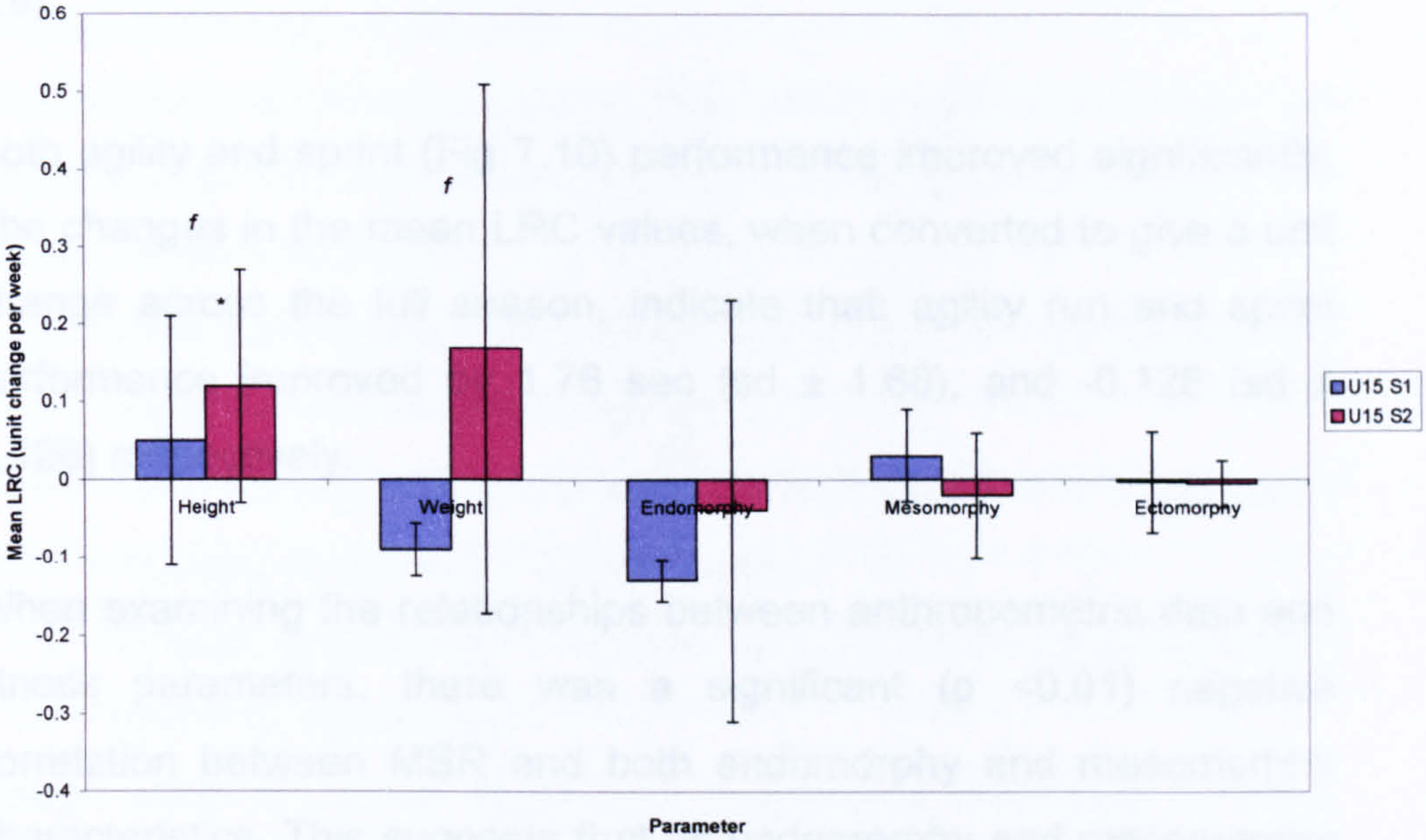

Figure 7.9: Mean LRC values: Under 15s, anthropometric data[1]

The mean LRC values for the fitness parameter data, collected in the under 15s age group is presented in Fig 7.10.

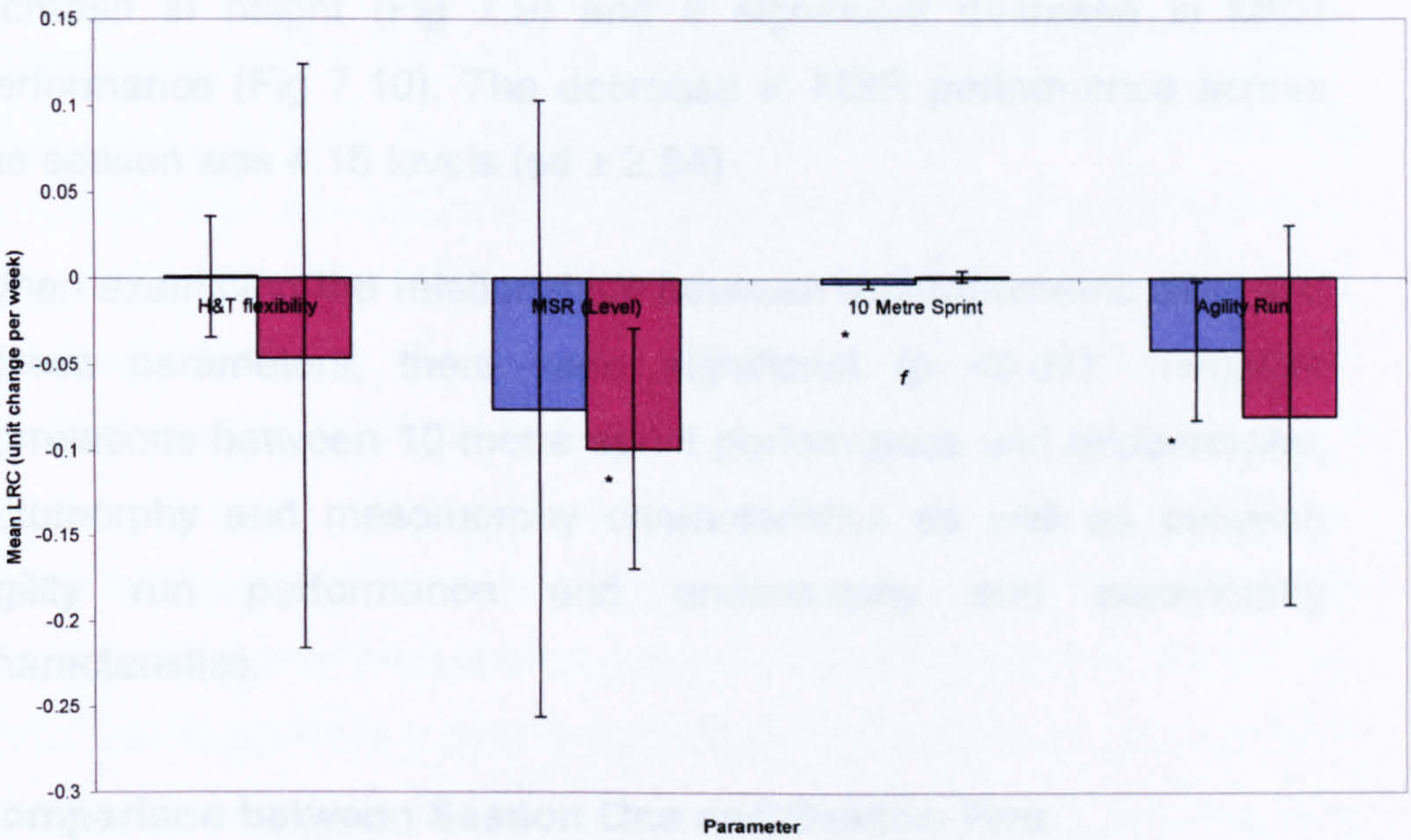

Fig 7.10: Mean LRC values: Under 15s, fitness parameter data[1]

Changes During Season One: Unrestricted Season

The under 15s age group in season one showed no statistical significant change for any of the anthropometric measurements (Fig 7.9).

Both agility and sprint (Fig 7.10) performance improved significantly. The changes in the mean LRC values, when converted to give a unit change across the full season, indicate that; agility run and sprint performance improved by 1.76 sec (sd ± 1.68), and -0.126 (sd ± 0.126) respectively.

When examining the relationships between anthropometric data and fitness parameters, there was a significant ($p < 0.01$) negative correlation between MSR and both endomorphy and mesomorphy characteristics. This suggests that as endomorphy and mesomorphy characteristics increase as MSR performance decreases.

Changes During Season Two: Restricted Season

The under 15s age group during season two showed a significant increase in height (Fig 7.9) and a significant decrease in MSR performance (Fig 7.10). The decrease in MSR performance across the season was 4.15 levels (sd ± 2.94).

When examining the relationships between anthropometric data and fitness parameters, there were significant ($p < 0.01$) negative correlations between 10-metre sprint performance and endomorphy, ectomorphy and mesomorphy characteristics as well as between agility run performance and endomorphy and ectomorphy characteristics.

Comparison between Season One and Season Two

The mean height change was greater in those subjects tested in the second season and the difference in the rate of change for sprint performance was significant (with season one improving and season two deteriorating slightly).

Overall Summary of Results

The following observations were made when examining the effect of restricting, to 36, the number of matches young soccer players are allowed to participate in:

- MSR performance decreased significantly in the under 11's, under 13, and under 14 age groups.
- Time taken to complete a run through cones was significantly reduced in the under 12 age group.
- Time taken to sprint 10 metres was significantly reduced in the under 15 age group.

There were no other significant differences observed between seasons one and two

7.4 Physiology Discussion

7.4.1 Study Design

There is no literature available on either; the effect of long term participation in competitive soccer or the effect of restricting children' participation in soccer has on their physical fitness. This study investigated the change in physical fitness of young soccer players across a soccer season, in which the players were allowed to participate in an unrestricted number of games. A comparison was then made with the results observed across a season where the subjects were restricted to 36 competitive matches. Activity logs and diaries were used in an attempt to ascertain the exact number of games players completed. Examination of the playing records for representative sides and results printed in the local press suggests a degree of underreporting of the competitive sport undertaken.

The repeated measures study design, employed in this study, is similar to those adopted in studies carried out in adult populations (Brady *et al.*, 1997; Casajus, 2001). These studies used a repeated measures ANOVA during the statistical analysis. However, it was not possible to employ the repeated measures ANOVA with the results of this thesis due to the occurrence of missing values. Excluding subjects with missing values would have reduced the sample size, thus reducing the validity of an application of the results to the general population. Consequently linear regression coefficients were used to replace the repeated measures ANOVA (Altman, 1991).

The likelihood of clubs releasing or transferring players at the end of season one, and subsequent change in personnel meant it was not possible to perform a year on year longitudinal study. As a result a comparison of age matched groups, between the two seasons was performed.

7.4.2 Anthropometric Data

When comparing the mean baseline values for height and weight in this study with the centile standards data for British children (Tanner and Whitehouse 1976) it is evident that; the mean data are equivalent to the 50^{th} percentile for the under 11, 12, and 14 age groups in those subjects tested in the first season; and the under 11, 12, 14 and 15 age groups in the second season. The values obtained in season one for the under 13s age group, and in the under 15s age group in season two are all equivalent to the 75^{th} percentile. With the value obtained, in season one, for the under 15s age group being equivalent to the 95^{th} percentile indicating that the subjects are taller than normative data. Baseline data for height and weight are similar to those at other FA registered academies (Lovell, Unpublished Data). As highlighted previously there is little literature examining the physiological profile of young soccer players and two of these studies use alternative systems for grouping the subjects. Therefore it is difficult to draw direct comparisons with other studies including details of young soccer players.

There was no significant difference between the season for baseline height and weight values in the under 11s, 12s, 14s, and 15s age groups. However both height and weight were significantly higher in season one compared to season two in the under 13s age group.

When examining the rate of change between the two seasons it is evident that the different groups of subjects increased in both height and weight at a faster rate in season two than in season one. Values calculated from the linear regression coefficients (LRC) indicate that in season one all the age groups grew at a significantly slower rate than figures given as the normative data by Tanner and Whitehouse (1976) (see Figures 7.1, 7.3, 7.5, 7.7, 7.9) although in season two the calculated growth rates were similar to those given by Tanner and Whitehouse (1976).

Summary - Anthropometric Data

The majority of young footballers observed in this study are of a similar height and weight to the normative data from 1976 (Tanner and Whitehouse,1976) and young footballers (Lovell, unpublished data). Whilst the rate of growth is greater in all the subjects tested in season two of this study compared to season one, this is still consistent with the rate of growth previously demonstrated (Tanner and Whitehouse, 1976).

7.4.3 Somatotype

Examination of the baseline somatotype data indicates that endomorphy contributes least to the phenotypical appearance of the subjects tested in both seasons of the study. This is consistent with the normative data for children (Duquet *et al.*, 1993). Baseline values for ectomorphy and mesomorphy are equal in the under 11s, 12s and 14s, in subjects tested in seasons one and two. This is in contrast to the work by Duquet *et al.*, (1993) who suggest that ectomorphy is the dominant characteristic in boys aged between 10 and 13, but decreases towards a balanced ectomorph-mesomorph physique approaching the age of 17. However, the baseline values obtained in the under 13s and 15s do show ectomorphy to be the dominant characteristics. This suggests that the subjects in the under 11s, 13s and 14s tested in seasons one and two of this study have a greater level of musculoskeletal development than the normative data possibly as a result of regular participation in competitive soccer (Duquet *et al.,* 1993).

Limited literature is available on the somatotype characteristics of young soccer players. Toteva (2002) carried out a study on 80 boys from sports schools, who were engaged in soccer. Of the age groups studied data was available in subjects equivalent to the under 13s, 14s and 15s. Toteva (2002) showed that the subjects equivalent to the under 13s in this study had somatotype characteristics classified as mesomorph-endomorph and demonstrated the under 14s and 15s were classified as ectomorph mesomorph. Where possible a comparison of age groups showed that the under 13s age group, in both season one and two, had a classification balanced mesomorph. This suggests a higher degree of musculoskeletal development than the under 13s age group in Totevas study. Both the under 14s and 15s age groups in Totevas' study had ectomorph-mesomorph characteristics. This is consistent with the values obtained in season one for the under 14s and both seasons one and two for the under 15s. Whilst there was no significant difference between seasons one and two in the under 14s there was a slight difference in the classification with the values for season two indicating a balanced mesomorph characteristic.

The young footballers observed in this study demonstrated a greater degree of musculoskeletal development, at baseline, than presented in normative data (Duquet *et al,* 1993). Whilst a precise comparison with other studies in young soccer players is not possible, it would appear that the players tested in this study have a greater degree of musculoskeletal development than other young soccer players (Toteva, 2002).

Endomorphy

When examining the rate of change across the two seasons there was no significant change in endomorphy across either season except in the under 14s age group in season two which increased slightly. This suggests an increase in the relative degree of fatness of the subjects. This could be as a result of the decrease in the number of game the individuals were allowed to participate in, and subsequent reduction in energy expenditure across the season. However, dietary analysis was beyond the scope of this study. The only difference in the rate of change for endomorphy was in the under 11s with season one being greater than season two. Whilst there was no significant difference in the rate of change across either season, the difference between the seasons can be accounted for by a non-significant increase in season one and a non-significant decrease across season two.

Mesomorphy

When examining the rate of change across the two seasons the under 12s and 13s age groups increased in musculo-skeletal characteristics across season one, as indicated by a significant increase in the LRC for mesomorphy. In season two the under 11s, 12s and 13s all showed a significant decrease in mesomorphy, with no change in either the under 14s or 15s. The decreases observed could be as a result of the increased rate of growth demonstrated during the second season.

The under 13s age group were the only age group to show a significant difference between seasons, with season one having a significantly higher LRC value than season two. This can be attributed to the significant increase demonstrated in season one and significant decrease demonstrated in season two, again this could be due to the increase in height.

Ectomorphy

When examining the rate of change in ectomorphy, across the two seasons, there is a significant decrease in the under 11s, 12s and 13s age groups. This could be as a result of the increase in muscular development in both the under 12s and 13s and a combination of the non-significant increase in endomorphy and mesomorphy in the under 11s age group. In season two there are decreases in both the under 11s and 13s this could again be due to non-significant changes in endomorphy and mesomorphy.

Summary of Anthropometric and Somatotype

The subjects observed in this study are of similar height and weight to normative data presented for British Children (Tanner and Whitehouse, 1976) and to young players at similar football academies (Lovell, unpublished data) with a greater degree of musculoskeletal development, at baseline, than presented in normative data (Duquet *et al.,* 1993). The players' increase in height and weight at a rate similar to the population norm (Tanner and Whitehouse, 1976).

7.4.4 Aerobic Capacity - Multistage Shuttle Run (MSR) Performance

The 20 metre progressive shuttle run test (MSR) is a method of assessing aerobic capacity in large groups of individuals with proven reliability and validity in adult populations (Ramsbottom *et al.*, 1988). However the applicability of the MSR to a child population has been questioned by a number of authors who suggest that the shuttle run test is more a reflection of the environment, the child's pace judgement and the potency of the motivational conditions under which the test takes place (Shephard, 1984; Armstrong, 1989). It was possible to overcome a number of these limitations by allowing a period of habituation, using an adult pacer who is well acquainted with the protocol and heart rate monitors to assess if the subjects attained a maximal effort. The MSR test is validated in an adult population and therefore prediction of aerobic capacity, from it, in children may be considered inaccurate (Hemmings *et al.*, 2003). This compounded with problems associated with the scaling of physiological data to account for changes due to growth and maturation were overcome in the following ways: First the data were presented as "performance on the MSR test as indicated by the level and beep number attained". This removed the possible error inherent in the prediction of VO_2 max from adult calculations. Second the statistical analysis was performed on the rate of change in MSR performance rather than comparing absolute or adjusted values. The linear regression coefficient technique used also overcame the problem associated with subjects' missing values. Finally the anthropometric data was correlated with the results from the physical fitness parameters in order to detect any relationship between changes in growth and maturation with the changes in physical fitness. This showed no significant correlation between the anthropometric and fitness data suggesting that growth and maturation were not responsible for the observed changes in physical fitness.

Comparison of baseline aerobic capacity with other similar studies is difficult due to the nature of the MSR test and the problems previously outlined. However it is possible to estimate the peak VO_2 of the subjects by converting the level attained on the MSR test using a simple table of values validated for adults (Ramsbottom *et al.*, 1988). The limitation of using this estimated value for a direct comparison is that the values given are validated for an adult population and there is no literature for the predictive values for VO_2 peak in children. However the predicted values, using adult conversion data, range from 40.5 $ml.kg.min^{-1}$ (in the under 11s) to 54.3 $ml.kg.min^{-1}$ (in the under 15s). These are similar to those values demonstrated in non-active children (Kemper and Verschuur, 1981; Leger *et al.*, 1988; Armstrong *et al.*, 1995; Bell, 1997) and lower than the values reported for young soccer players (Jones and Helms, 1991; Kohno *et al.*, 1997).

The findings in this study do not support the hypothesis in two ways: firstly the results do not show an increase in aerobic capacity in either season, and secondly the performance on the MSR test had decreased significantly at the end of the restricted season more than at the end of the unrestricted season.

During the first season of the study only the under 14 age group showed any significant increase in MSR performance. Whilst there was no significant increase in the other age groups, the significant increase in the under 14s age group is consistent with Mirwald *et al.*, (1981) who showed the largest rate of increase in aerobic capacity to be in the under 14s. During the second season none of the groups showed an increase, with the under 11s, 13s and 15s age groups all showing a significant decrease in MSR performance. This, again, supports the findings of Mirwald *et al.*, (1981) as the under 14s maintained their aerobic capacity whilst the other age groups showed a significant decrease. It is suggested that these findings may be the result of the onset of puberty contributing more to the effect of growth and maturation on aerobic capacity in the under 14s than is evident in the other age groups (Mirwald *et al.*, 1981).

When comparing the linear regression coefficient (LRC) values for the two seasons the under 11s and 14s showed a significantly higher mean LRC value in season one than in season two. In the case of the under 11s age group this can be accounted for by the decrease in performance in season two being significant with no significant change in season one. In the under 14s age group the difference between seasons can be accounted for by the MSR performance increasing significantly in season one, with a non-significant decrease in season two. These results suggest that limiting the number of competitive games the subjects participated in resulted in a decrease in aerobic fitness in the under 11s, 13s, 14s and 15s. Examination of the relationships between the fitness parameters and anthropometric data shows no significant relationships in any of the age groups. This may explain why there was no significant increase in the MSR performance in season one, but fails to account for the decrease in MSR performance demonstrated in season two. Analyses of the individual LRC values shows that; in the first season the number of subjects demonstrating an increase and the number demonstrating a decrease in aerobic capacity were similar in most age groups. However in the under 14s age group the majority of the subjects (11/12) increased their aerobic capacity over the season with only one showing a decrease in aerobic capacity. In the second season, in the age groups demonstrating a decrease in aerobic capacity, only one subject actually demonstrated an increase in their aerobic capacity. Hence it is evident that individuals differ in their response to the physical stimulus they are subjected to over a competitive season. However it is possible that the changes in individual's fitness are masked by the group mean data.

The ACSM guidelines (1990) and Rowland (1992) suggest that improvement in aerobic fitness is inversely proportional to the initial aerobic fitness levels (ACSM, 1978; 1990; Rowland, 1992). The difference in rate of change between the seasons could be due to differing levels of aerobic fitness at baseline. However, examination of the baseline aerobic fitness levels showed no significant difference between the unrestricted and restricted seasons.

The failure to increase aerobic capacity across the first (unrestricted) season is in accordance with the limited research available on the effect of competitive soccer on aerobic fitness (all-be-it in adults) (Siegler *et al.*, 2003). This could be as a result of a lack of progression in physical stimulus across the season (Hoffman, 2002b). To increase aerobic fitness progression is required in the intensity of the physical training stimulus the subjects are exposed to. Competitive soccer is unlikely to demonstrate the required progression across a season, as the physiological demands of match play remain reasonably constant across a season. The fitness levels may increase initially at the start of pre-season, and then remain constant as the continued participation in competitive soccer provides sufficient stimulus to maintain fitness, but lacks the progression required to increase physical fitness further. These the findings are similar to the findings of short term studies (Mosher *et al* 1985; Berg *et al* 1985) who found no significant increases in aerobic capacity in young soccer players subjected only to conventional skills and tactical training and competitive matches. Recently Siegler *et al.*, (2003) demonstrated that including a high-intensity training programme during a 10-week competitive season resulted in an improvement in aerobic capacity in female high school soccer players. Hoff *et al.*, (2002) showed that improvements in aerobic capacity are possibly with soccer specific exercise training using ball dribbling or small group play if sufficient work intensity is attained.

Summary

The data would suggest that, over an unrestricted season, participation in competitive soccer does not result in an increase in aerobic capacity, and aerobic capacity decreases across a restricted season.

It is also possible to explain the observed decrease in aerobic fitness during the restricted season (two) as limiting the number of competitive matches young players are allowed to participate in removes the physical stimulus required to maintain aerobic capacity resulting in the observed decrease (Hoffman, 2002a).

7.4.5 10 Metre Sprint Performance

Soccer has been shown to involve regular bouts of all-out sprinting (O'Donoghue, 2003). It is hypothesised that repeated exposure to regular bouts of all-out sprinting during a competitive soccer season may result in an improvement in sprint performance as indicated by a decrease in the time taken to sprint 10 metres. Limiting the number of games to 36 may also result in an improvement in sprint performance as a result of the regular bouts of all-out sprinting. However due to the reduced number of games played the improvement in performance is hypothesised to be smaller than in the unrestricted season.

The first part of the hypothesis is supported by the data from the under 11s, 12s and 15s groups who all demonstrated a significant improvement in sprint performance, as indicated by a decrease in time take to complete a 10 metre sprint.

The majority of the data from season two (restricted) do not support the second part of the hypothesis. Only the under 14s demonstrated a significant improvement in performance, with the remaining age groups showed no significant change in sprint performance. The improvement in performance in the under 14s could be, as previously hypothesised, as a result of the onset of puberty contributing more to the effect of growth and maturation on sprint performance in the under 14s than is evident in the other age groups (Mirwald *et al.*, 1981).

Baseline measures of time taken to sprint 10 metres were compared in order to investigate if the subjects tested in season two were significantly quicker than those tested in season one. Improvements in fitness have been shown to be inversely proportional to baseline value (Rowland, 1992). In this case smaller improvements, in sprint performance, would be expected if one group were quicker than another at baseline. However with no differences observed, at baseline, between any of the groups baseline values were not responsible for the observed differences in the rate of change over the two seasons. The values obtained at baseline for the 10 metre sprint time in each of the age groups is roughly equal to that of other elite young soccer players of similar ages (Strudwick 2002 unpublished data; Lovell, unpublished data).

The observed increase in sprint performance across season one and the lack of improvement in sprint performance across season two could be explained by the repeated exposure to regular bouts of all-out sprinting during an unrestricted competitive soccer season. This results in sufficient training stimulus to illicit an improvement in sprint performance. However, in limiting the number of games to 36 that young players are allowed to participate in could remove the stimulus required to illicit the improvement observed in season one thus resulting in no significant improvement in sprint performance.

Summary

As such the data would suggest that, over an unrestricted season, participation in competitive soccer results in an improvement in sprint performance, as indicated by a decrease in the time taken to sprint 10 metres. However over a season with the number of games young players are allowed to participate in limited to 36, there is no improvement in sprint performance.

7.4.6 Agility Performance - Run Through Cones

The exact nature of the factors that contribute to agility have not been directly determined, but it does depend on muscular power, reaction time, co-ordination and dynamic flexibility (Kent 1998). Children have usually developed the fundamental motor skills by the age of 6 or 7 (Malina and Bouchard 1991; Watkins 2000), however further developments can be refined through practice and instruction and as the quality and quantity of performance improve, the patterns are integrated into more complex motor activities (Malina and Bouchard 1998) such as those demonstrated in soccer. It is hypothesised that repeated exposure, across a full unrestricted season, to the movement patterns in soccer will result in an improvement in a run through cones that represents the movement patterns commonly found in soccer. Limiting the number of games to 36 will still result in a significant improvement in performance as a result of the movement patterns undertaken. However due to the reduced number of games played the improvement in performance will be smaller than in the unrestricted season.

The data from this study support the first part of the hypothesis with the under 12, 14 and 15 age groups all demonstrating a significant improvement in performance across the unrestricted season (season one), as indicated by a decrease in time take to complete a run through cones. However the data does not fully support the second part of the hypothesis. During season two of the study the under 11s demonstrated a significant improvement in performance which was greater than the non-significant change observed across the first season. The remaining age groups showed no significant change across the second season. When comparing the LRC values for the two seasons the under 12s demonstrated a significantly greater rate of change during the first season than in the second season, with the LRC values demonstrating a significant improvement in performance in the first season and no significant change in the second season.

This could be explained by repeated exposure, across a full unrestricted season, to the movement patterns in soccer resulting in an improvement in a run through cones that represent the movement patterns commonly found in soccer. However limiting the number of games young players are allowed to participate in could remove the stimulus required to elicit the improvement observed in season one thus resulting in no significant improvement in sprint performance. There is currently no literature available, examining the effect of soccer participation on the agility of children.

Summary

The data would suggest that, over an unrestricted season, participation in competitive soccer results in an improvement in agility run performance, as indicated by a decrease in the time taken to complete a run through cones. However over a season with the number of games young players are allowed to participate in is limited to 36, there is no improvement in agility run performance.

Conclusions

The data from this study suggests that the physical stimulus of competitive soccer across an unrestricted season is sufficient to maintain aerobic fitness, and improve both 10 metre sprint and agility run performance.

Limiting to 36 the number of competitive games young players are allowed to participate results in a reduction in aerobic capacity and no improvement in either 10 metre sprint or agility run performance. Therefore limiting the number of games has a detrimental effect on the physical fitness of elite young soccer players.

Chapter 8: Psychology

8.1 Introduction

The review of literature for this study is situated in section 3 of the thesis.

Aims and Objectives

To utilize psychological markers of mood states and qualitative measures of the sources and symptoms of stress combined in order to investigate the effect of limiting the number of games you players are allowed to participate in has on the levels of stress experienced over a complete soccer season.

8.2 Methodology

The details of the psychological methodology adopted are outlined in section 6.4. Information regarding the subject numbers included in the psychology section is presented in Table 8.1. It is notable that whilst the all subjects recruited during the study were asked to complete the psychological questionnaires, not all returned the questionnaires. As such there are less subject numbers than included in the physiology section

Table 8.1: Subject numbers in the psychology study

Age Group	*Season One*	*Season Two*
Under 11	8	4
Under 12	10	7
Under 13	11	9
Under 14	8	5
Under 15	6	2

There were insufficient responses, for the under 15 age group during season two, for statistical analysis to be carried out.

8.3 Results Section

During this study Baseline data, collected in the week immediately prior to the start of pre-season training as is referred to as week 0. The data collected in the last week of the season is referred to as week 42.

Under 11

Season One.

BRUMS

Season one (unrestricted) mean group data (Week 0 and Week 42) is shown in Table 8.2.

Table 8.2: Under 11 BRUMS scores for season one of the study. (Significance is accepted at p<0.05)

Mood State	Week 0 Score (SD)	Week 42 Score (SD)	Comparison
TMD	93.50 (8.50)	114.25 (3.01)	**Week 0 < Week 42**
Tension	1.38 (1.85)	6.38 (0.52)	**Week 0 < Week 42**
Depression	0.00 (0.00)	0.13 (0.35)	NS
Anger	0.88 (1.73)	6.63 (1.19)	**Week 0 < Week 42**
Vigour	12.13 (3.18)	0.50 (0.53)	**Week 0 > Week 42**
Fatigue	2.38 (3.20)	0.13 (0.35)	NS
Confusion	1.00 (1.60)	1.50 (1.85)	NS

In season one of the study the TMD score increased significantly from Week 0 to Week 42.

Of the individual mood states (Fig 8.1) both tension and anger increased significantly from Week 0 to Week 42. Vigour decreased significantly from Week 0 to Week 42.

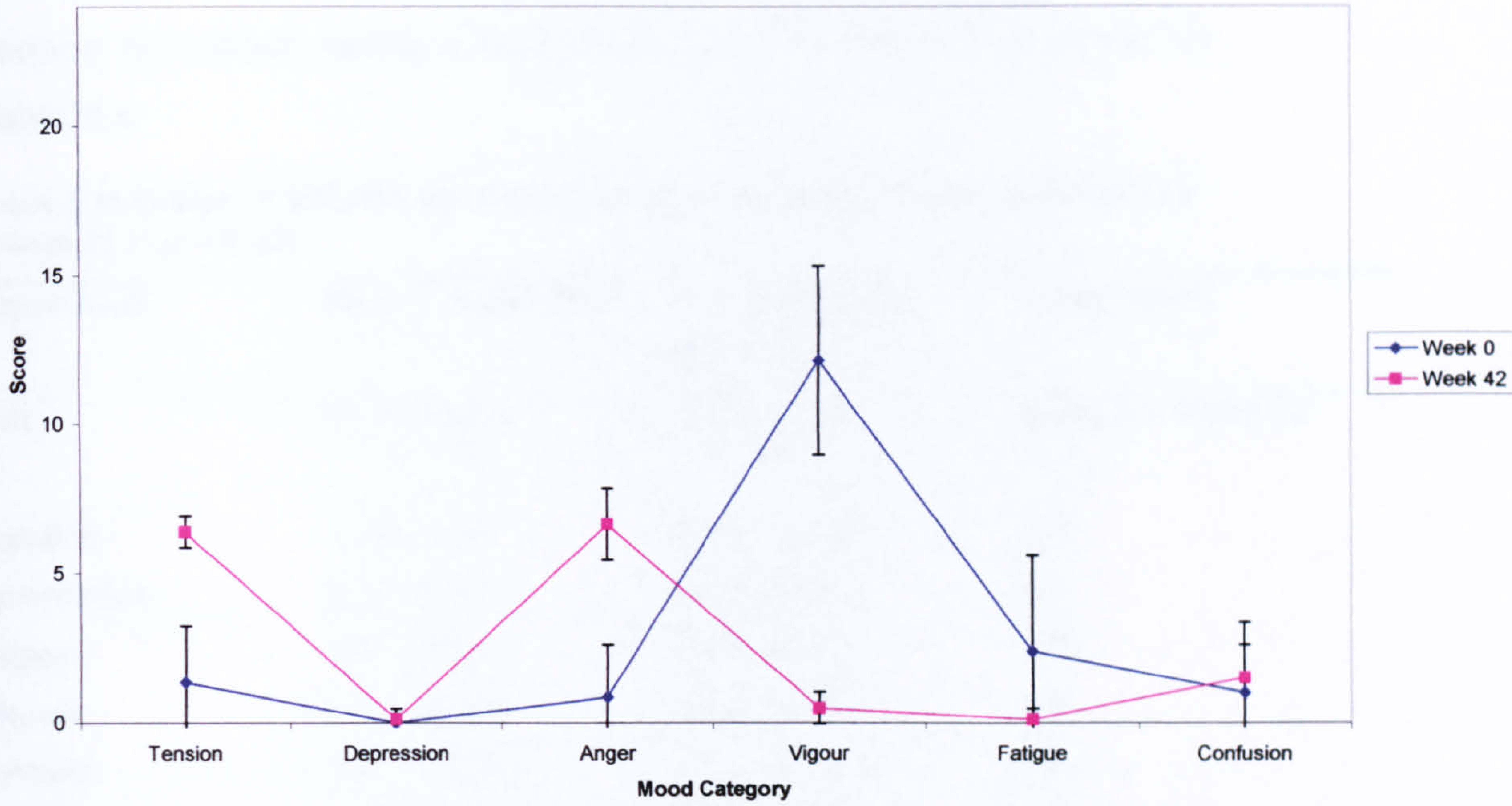

Figure 8.1 BRUMS: Season One. Under 11 Individual mood states profile: Pre- and Post-Season

Daily Analysis of Life Demands in Athletes (DALDA)

Season one mean group data (Week 0 and Week 42) are shown in Table 8.3.

Table 8.3: Mean number of "a" answers[1], for the Under 11 age group, for the DALDA: Season one (significance accepted at $p < 0.05$)

Section	Week 0 (sd)	Week 42 (sd)	Comparison
A (Sources of Stress)	0.50 (0.71)	0.40 (0.96)	NS
B (symptoms of stress)	1.00 (1.76)	1.90 (3.78)	NS
Total	1.50 (2.27)	2.30 (4.69)	NS

There were no significant differences between Week 0 and Week 42 of the study with the number of sources and symptoms of stress being recorded as "worse than normal" being low.

[1] When completing the modified DALDA an "a answer" indicates the chosen parameter is identified as being "worse than normal"

Season Two

BRUMS

Season two mean group data (Week 0 and Week 42) is shown in Table 8.4.

Table 8.4: Under 11 BRUMS scores for season two of the study (significance accepted at $p < 0.05$)

Mood State	Week 0 score (SD)	Week 42 Score (SD)	Comparison
TMD	97.40 (6.50)	92.80 (7.40)	**Week 0 > Week 42**
Tension	1.25 (1.50)	0.00 (0.00)	NS
Depression	0.50 (0.57)	0.00 (0.00)	NS
Anger	1.0 (1.41)	0.00 (0.00)	NS
Vigour	9.0 (6.48)	11.25 (3.94)	NS
Fatigue	1.0 (1.91)	0.75 (1.50)	NS
Confusion	1.5 (1.91)	0.25 (0.50)	NS

In season two of the study the TMD score (Fig 8.2) decreased significantly from Week 0 to Week 42 with no other significant changes.

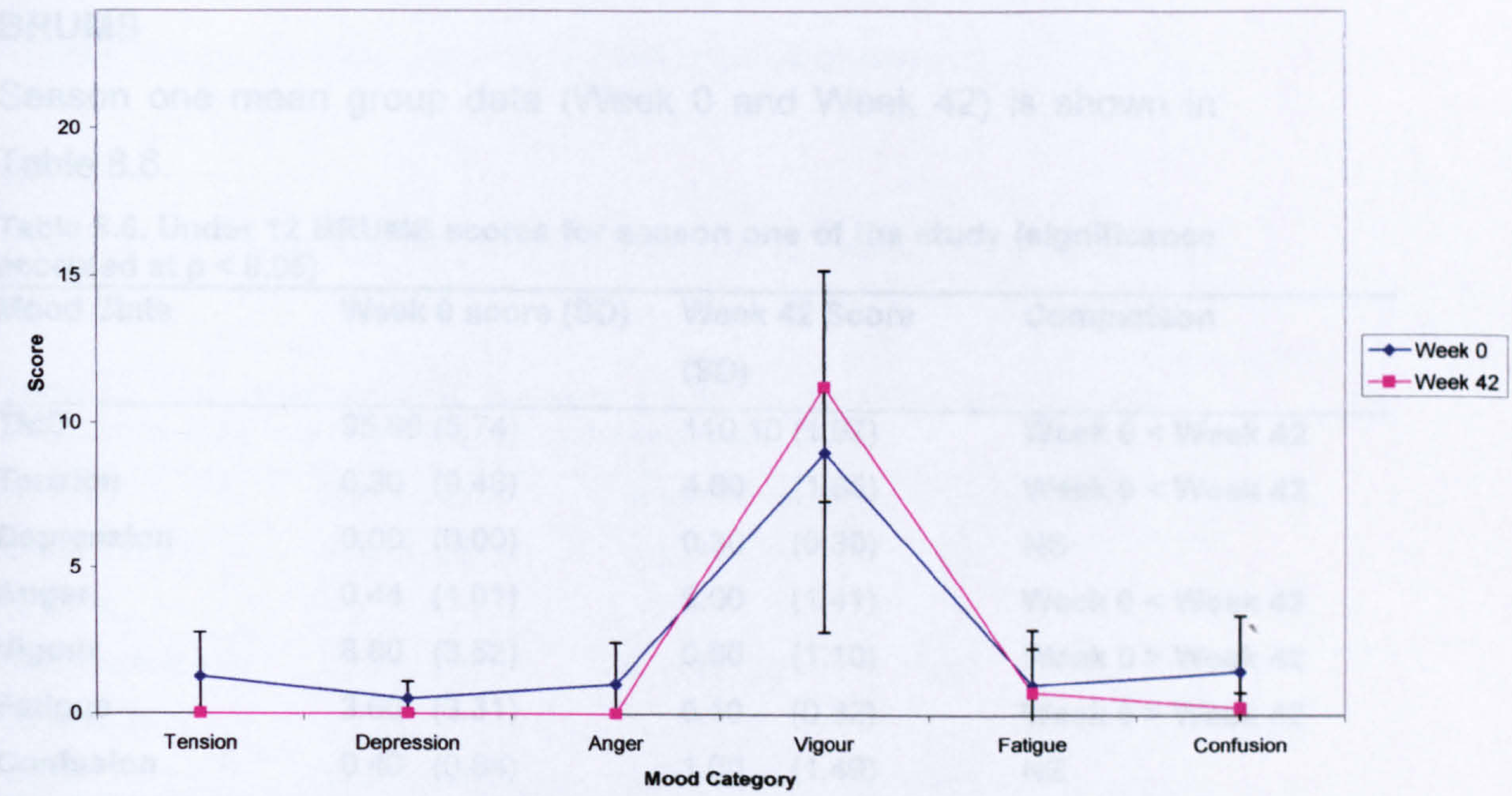

Figure 8.2 BRUMS: Season Two. Under 11 Individual mood states profile. Pre- and Post-season

There were no significant differences between Week 0 and Week 42 for any of the individual mood states.

DALDA

Season two mean group data (Week 0 and Week 42) is shown in Table 8.5.

Table 8.5: Mean number of "a" answers, for the Under 11 age group, for the DALDA: Season two (significance accepted at $p < 0.05$)

Section	Week 0 (sd)	Week 42 (sd)	Comparison
A (Sources of Stress)	0.37 (0.52)	0.12 (0.35)	NS
B (Symptoms of Stress)	0.50 (1.07)	0.50 (1.41)	NS
Total	0.87 (0.99)	0.62 (1.40)	NS

There were no significant differences between Week 0 and Week 42 for the under 11s, season two of the study.

Under 12

Season One.

BRUMS

Season one mean group data (Week 0 and Week 42) is shown in Table 8.6.

Table 8.6. Under 12 BRUMS scores for season one of the study (significance accepted at $p < 0.05$)

Mood State	Week 0 score (SD)	Week 42 Score (SD)	Comparison
TMD	95.90 (5.74)	110.10 (1.97)	**Week 0 < Week 42**
Tension	0.30 (0.48)	4.60 (1.65)	**Week 0 < Week 42**
Depression	0.00 (0.00)	0.30 (0.30)	NS
Anger	0.44 (1.01)	5.00 (1.41)	**Week 0 < Week 42**
Vigour	8.80 (3.52)	0.90 (1.10)	**Week 0 > Week 42**
Fatigue	3.60 (3.31)	0.10 (0.32)	**Week 0 > Week 42**
Confusion	0.40 (0.84)	1.00 (1.49)	NS

In season one of the study the TMD score decreased significantly from Week 0 to Week 42.

Of the individual mood states (Fig 8.3) tension, anger, and fatigue all increased significantly from Week 0 to Week 42. Vigour decreased significantly from Week 0 to Week 42.

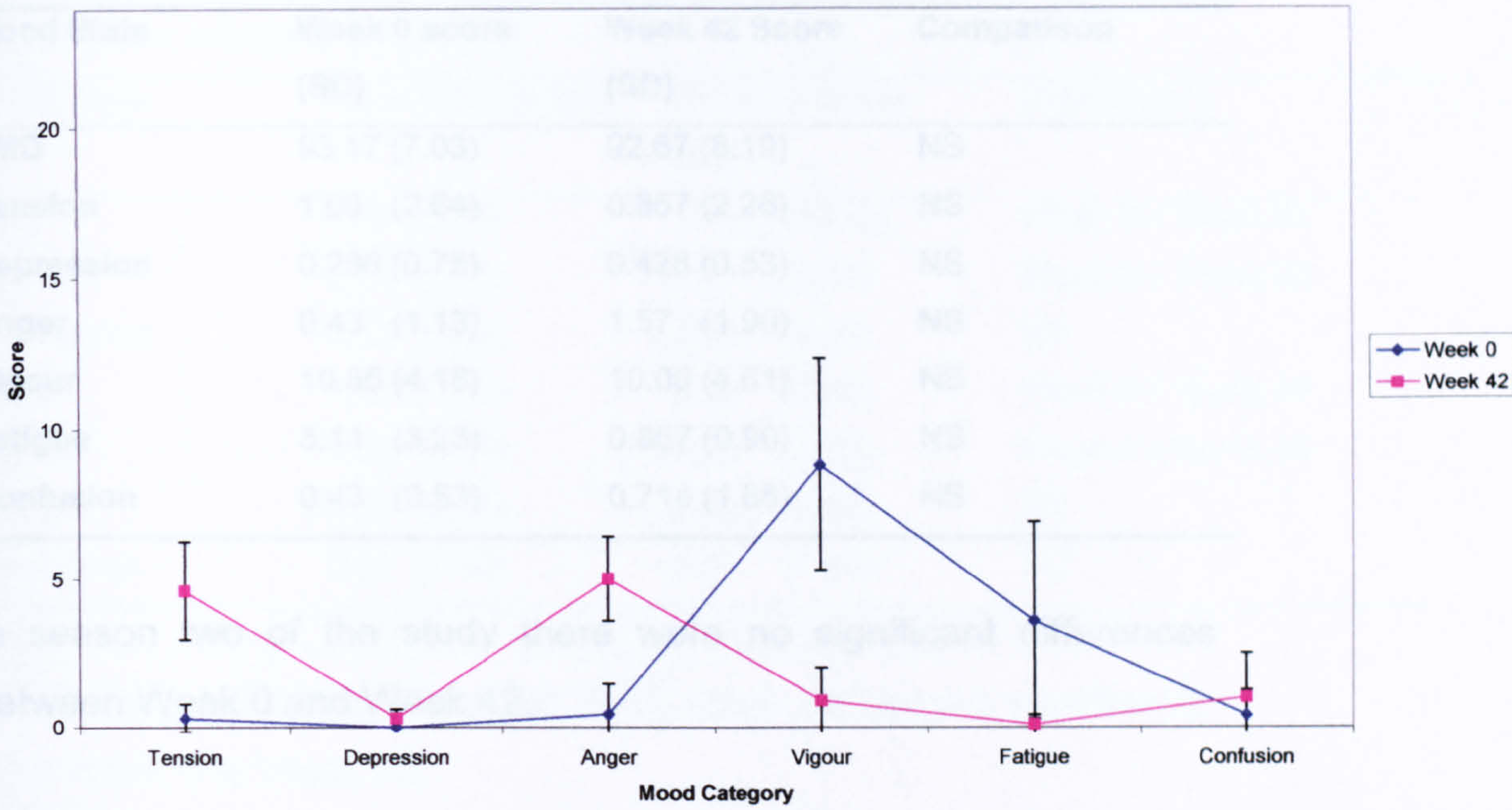

Figure 8.3. Season One Under 12 BRUMS: Individual Mood

DALDA

Season one mean group data (Week 0 and Week 42) is shown in Table 8.7.

Table 8.7. Mean number of "a" answers, for the Under 12 age group, for the DALDA: Season one (significance accepted at $p < 0.05$)

Section	Week 0 (sd)	Week 42 (sd)	Comparison
A (Sources of Stress)	0.30 (0.48)	0.50 (1.08)	NS
B (Symptoms of Stress)	0.70 (1.05)	0.10 (0.32)	NS
Total	1.00 (1.25)	0.60 (1.26)	NS

There were no significant differences between Week 0 and Week 42 of the study.

Season Two

BRUMS

Season two mean group data (Week 0 and Week 42) is shown in Table 8.8.

Table 8.8: Under 12 BRUMS scores for season two of the study (significance accepted at $p < 0.05$)

Mood State	Week 0 score (SD)	Week 42 Score (SD)	Comparison
TMD	93.17 (7.03)	92.67 (8.19)	NS
Tension	1.00 (2.64)	0.857 (2.26)	NS
Depression	0.286 (0.75)	0.428 (0.53)	NS
Anger	0.43 (1.13)	1.57 (1.90)	NS
Vigour	10.85 (4.18)	10.00 (4.61)	NS
Fatigue	3.14 (3.23)	0.857 (0.90)	NS
Confusion	0.43 (0.53)	0.714 (1.88)	NS

In season two of the study there were no significant differences between Week 0 and Week 42.

DALDA

Season two mean group data (Week 0 and Week 42) is shown in Table 8.9.

Table 8.9: Mean number of "a" answers, for the Under 12 age group, for the DALDA: Season two (significance accepted at $p < 0.05$)

Section	Week 0 (sd)	Week 42 (sd)	Comparison
A (Sources of Stress)	0.44 (0.73)	1.55 (2.13)	NS
B (Symptoms of Stress)	1.88 (3.01)	3.88 (3.91)	**Week 0 < Week 42**
Total	2.33 (3.57)	5.44 (5.72)	**Week 0 < Week 42**

The number of "a" answers given in section B and in total increased significantly from Week 0 to Week 42 in season two of the study indicating an increase in the number of symptoms of stress being reported as "worse than normal".

Under 13

Season One.

BRUMS

Season one mean group data (Week 0 and Week 42) is shown in Table 8.10.

Table 8.10: Under 13 BRUMS scores for season one of the study (significance accepted at $p < 0.05$)

Mood State	Week 0 score (SD)	Week 42 Score (SD)	Comparison
TMD	97.64 (6.95)	114.45 (10.88)	**Week 0 < Week 42**
Tension	0.27 (0.65)	5.27 (3.66)	**Week 0 < Week 42**
Depression	0.82 (1.08)	2.00 (3.49)	NS
Anger	1.09 (1.76)	5.36 (2.62)	**Week 0 < Week 42**
Vigour	9.00 (4.71)	2.00 (1.67)	**Week 0 > Week 42**
Fatigue	4.00 (2.61)	1.55 (2.58)	NS
Confusion	0.45 (0.93)	2.27 (1.68)	NS

In season one of the study the TMD score decreased significantly from Week 0 to Week 42.

Of the individual mood states (Fig 8.4) both tension and anger increased significantly from Week 0 to Week 42. Vigour decreased significantly from Week 0 to Week 42.

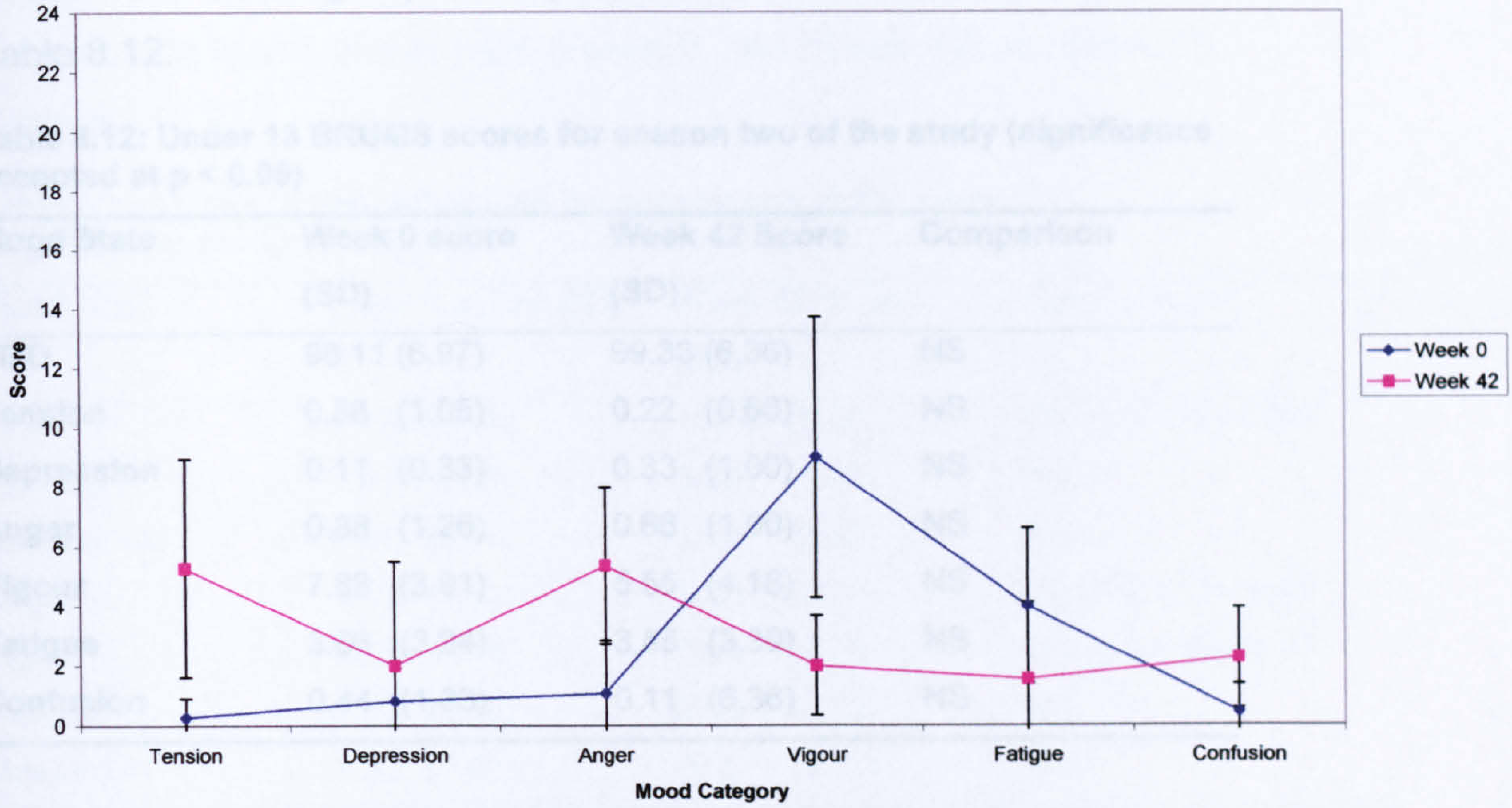

Figure 8.4: Season one Under 13: BRUMS Individual Mood Scores

DALDA

Season one mean group data (Week 0 and Week 42) is shown in Table 8.11.

Table 8.11. Number of "a" answers, for the Under 13 age group, for the DALDA: Season one (significance accepted at $p < 0.05$)

Section	**Week 0 (sd)**	**Week 42 (sd)**	**Comparison**
A (Sources of Stress)	0.22 (0.44)	0.44 (1.01)	NS
B (Symptoms of Stress)	0.00 (0.00)	0.77 (1.09)	**Week 0 < Week 42**
Total	0.22 (0.44)	1.22 (1.72)	NS

The number of "a" answers increased significantly lower, in section b from Week 0 to Week 42 in season one of the study. There were no other significant differences.

Season Two

BRUMS

Season two mean group data (Week 0 and Week 42) is shown in Table 8.12.

Table 8.12: Under 13 BRUMS scores for season two of the study (significance accepted at $p < 0.05$)

Mood State	Week 0 score (SD)	Week 42 Score (SD)	Comparison
TMD	98.11 (6.97)	99.33 (6.36)	NS
Tension	0.88 (1.05)	0.22 (0.66)	NS
Depression	0.11 (0.33)	0.33 (1.00)	NS
Anger	0.88 (1.26)	0.66 (1.00)	NS
Vigour	7.88 (3.91)	5.55 (4.18)	NS
Fatigue	3.66 (3.24)	3.55 (3.39)	NS
Confusion	0.44 (1.33)	0.11 (6.36)	NS

In season two of the study there were no significant differences between Week 0 and Week 42. There was no significant difference between any of the individual mood states scores.

DALDA

Season two mean group data (Week 0 and Week 42) is shown in Table 8.13.

Table 8.13: Number of "a" answers, for the Under 13 age group, for the DALDA: Season one (significance accepted at $p < 0.05$)

Section	Week 0 (sd)	Week 42 (sd)	Comparison
A (Sources of Stress)	0.40 (0.52)	0.50 (0.98)	NS
B (Symptoms of Stress)	1.40 (2.55)	1.40 (2.63)	NS
Total	1.80 (2.65)	1.90 (3.51)	NS

There were no significant differences between Week 0 and Week 42 of the study.

Under 14

Season One.

BRUMS

Season one mean group data (Week 0 and Week 42) is shown in Table 8.14.

Table 8.14: Under 14 BRUMS scores for season one of the study. (Significance accepted at $p<0.05$)

Mood State	Week 0 score (SD)	Week 42 Score (SD)	Comparison
TMD	96.63 (5.04)	110.63 (6.09)	**Week 0 < Week 42**
Tension	1.38 (2.00)	3.50 (2.00)	NS
Depression	0.25 (0.71)	1.50 (2.45)	NS
Anger	1.00 (1.51)	5.50 (2.73)	**Week 0 < Week 42**
Vigour	9.50 (3.78)	0.50 (0.76)	**Week 0 > Week 42**
Fatigue	2.50 (2.78)	0.13 (0.35)	NS
Confusion	1.00 (1.60)	0.50 (0.76)	NS

In season one of the study the TMD score increased significantly higher from Week 0 to week 42.

Of the individual mood states (Fig 8.5) anger increased significantly from Week 0 to week 42. Vigour decreased significantly from Week 0 to Week 42.

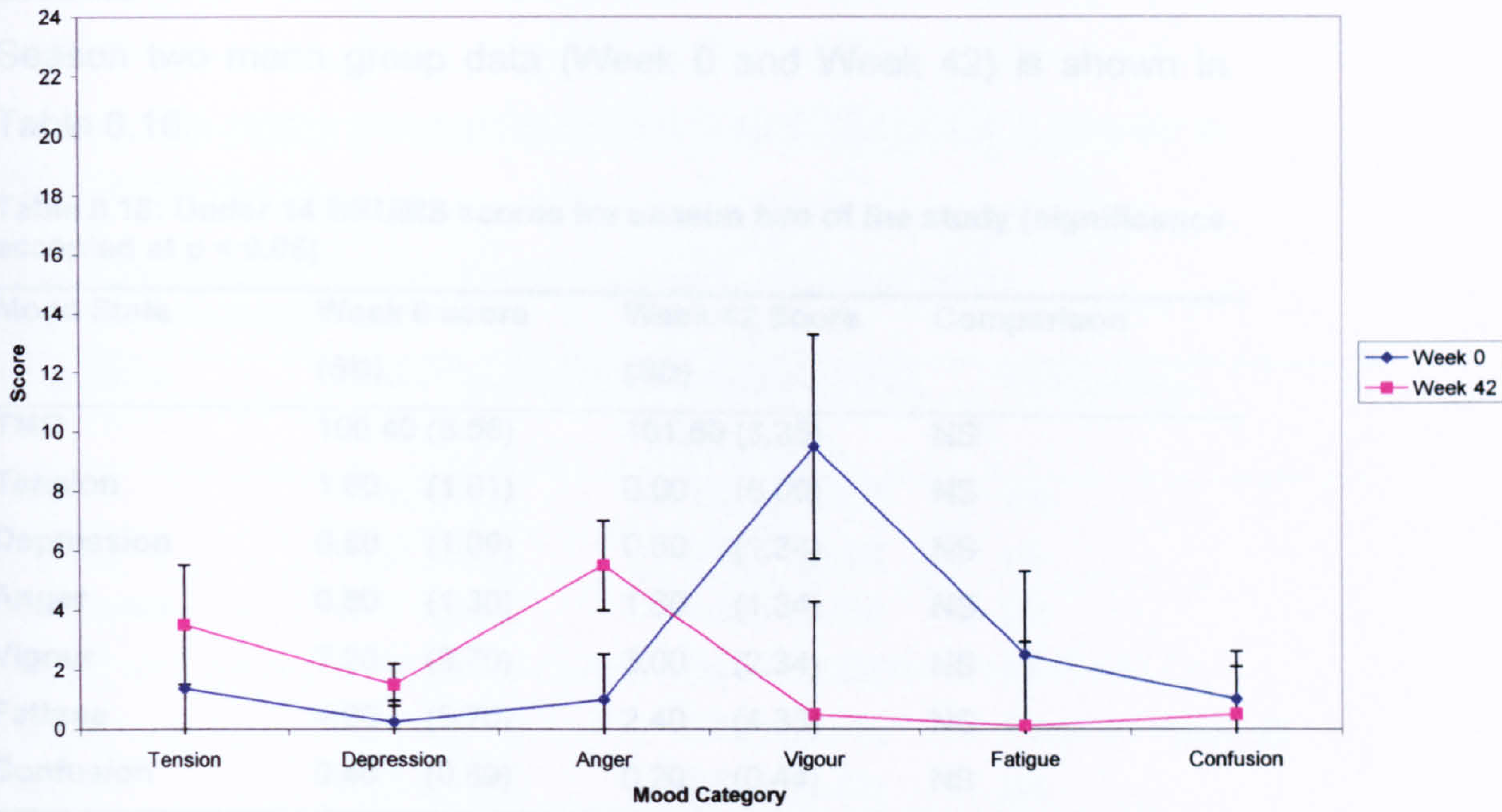

Figure 8.5: Season One Under 14: BRUMS Individual Mood Scores

DALDA

Season one mean group data (Week 0 and Week 42) is shown in Table 8.15.

Table 8.15: Number of "a" answers, for the Under 14 age group, for the DALDA: Season one (significance accepted at $p < 0.05$)

Section	Week 0 (sd)	Week 42 (sd)	Comparison
A (Sources of Stress)	0.23 (0.44)	0.31 (0.48)	NS
B (Symptoms of Stress)	0.46 (1.27)	0.23 (0.44)	NS
Total	0.69 (1.10)	0.54 (0.52)	NS

There were no significant differences between Week 0 and Week 42 of the study.

Season Two

BRUMS

Season two mean group data (Week 0 and Week 42) is shown in Table 8.16.

Table 8.16: Under 14 BRUMS scores for season two of the study (significance accepted at $p < 0.05$)

Mood State	Week 0 score (SD)	Week 42 Score (SD)	Comparison
TMD	100.40 (8.56)	101.80 (3.35)	NS
Tension	1.60 (1.81)	0.00 (0.00)	NS
Depression	0.80 (1.09)	0.60 (1.34)	NS
Anger	0.80 (1.30)	1.60 (1.34)	NS
Vigour	7.20 (3.70)	3.00 (2.34)	NS
Fatigue	4.00 (5.70)	2.40 (4.33)	NS
Confusion	0.40 (0.89)	0.20 (0.44)	NS

In season two of the study there were no significant differences between Week 0 and Week 42. There was no significant difference between any of the individual mood states scores.

DALDA

Season two mean group data (Week 0 and Week 42) is shown in Table 8.17.

Table 8.17: Number of "a" answers, for the Under 14 age group, for the DALDA: Season two

Section	Week 0 (sd)	Week 42 (sd)	Comparison
A (Sources of Stress)	0.80 (1.09)	0.40 (0.55)	NS
B (Symptoms of Stress)	0.80 (1.30)	0.20 (0.45)	NS
Total	1.60 (2.07)	0.60 (0.89)	**Week 0 > Week 42**

In season two of the study there were no significant differences between Week 0 and Week 42.

Under 15

Season One.

BRUMS

Season one mean group data (Week 0 and Week 42) is shown in Table 8.18.

Table 8.18: Under 15 BRUMS scores for season one of the study (significance accepted at $p < 0.05$)

Mood State	Week 0 score (SD)	Week 42 Score (SD)	Comparison
TMD	10.83 (8.56)	112.50 (5.21)	NS
Tension	1.50 (2.51)	5.00 (2.45)	NS
Depression	1.50 (2.51)	1.33 (1.75)	NS
Anger	2.50 (2.81)	5.33 (2.34)	NS
Vigour	7.83 (2.79)	2.00 (2.76)	**Week 0 > Week 42**
Fatigue	5.83 (4.26)	0.67 (1.03)	NS
Confusion	1.33 (2.16)	2.17 (2.32)	NS

In season one of the study there was no significant difference between TMD scores, however of the individual mood states vigour was significantly higher in Week 0 of the study compared with Week 42 (Fig 8.6).

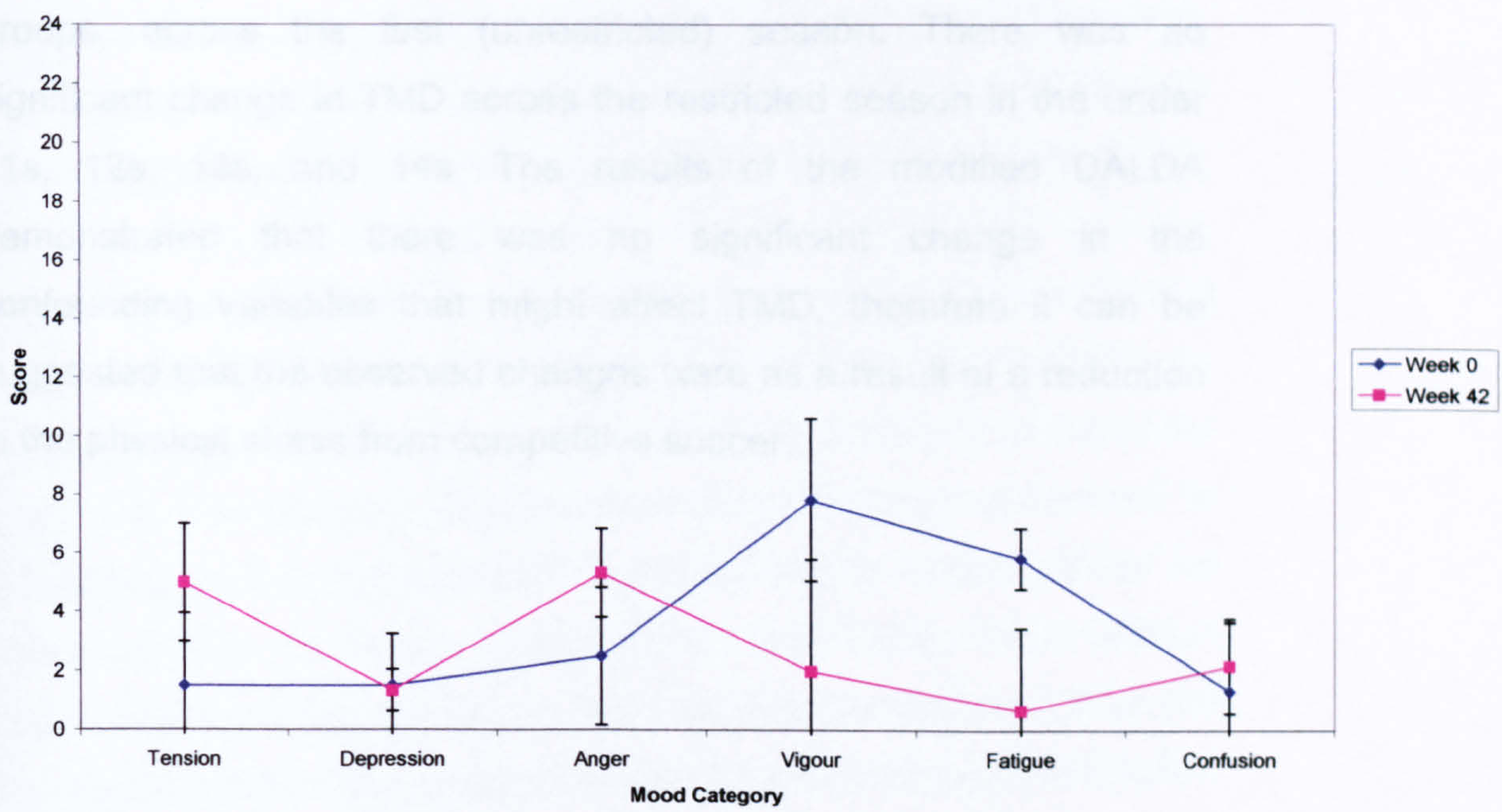

Figure 8.6: Season one Under 15: BRUMS Individual Mood States Profile

DALDA

Season one mean group data (Week 0 and Week 42) is shown in Table 8.19.

Table 8.19: Number of "a" answers, for the Under 15 age group, for the DALDA: Season one

Section	Week 0 (sd)	Week 42 (sd)	Comparison
A (Sources of Stress)	1.09 (1.22)	0.82 (1.47)	NS
B (Symptoms of Stress)	1.91 (3.80)	1.36 (1.96)	NS
Total	3.00 (4.86)	2.18 (3.16)	NS

There were no significant differences between Week 0 and Week 42 of the study.

There were insufficient responses, for the under 15 age group, in the second season for statistical analysis to be carried out. Consequently it was not possible to compare the results of the data collected during the two seasons.

Overall Summary of Psychology Results

In this study total mood disturbance (TMD) increased, in all age groups, across the first (unrestricted) season. There was no significant change in TMD across the restricted season in the under 11s, 12s, 13s, and 14s. The results of the modified DALDA demonstrated that there was no significant change in the confounding variables that might affect TMD, therefore it can be suggested that the observed changes were as a result of a reduction in the physical stress from competitive soccer.

8.4 Psychology Discussion

The findings of this study failed to support the hypothesis as there was an increase in total mood disturbance (TMD) in all age groups tested across the first season. During the second season TMD decreased in the under 11's with no other significant changes. The decrease in TMD observed in the under 11s group occurred as a result of an increase in vigour and simultaneous decrease in tension, and confusion. Research investigating training load on mood states has consistently shown mood states to change in a dose dependent manner with TMD increasing with training load and then decreasing with a period of tapering (Morgan *et al.*, 1987; Morgan *et al.*, 1988; Murphy *et al.*, 1990; Raglin *et al.*, 1991). The results of this study suggest that, in all age groups, the training load experienced by the athletes was greater in the players tested in the first season than in those tested in the second season. This is indicated by the significant increase in TMD across the first season, with no significant change in those subject tested during the second season. There was no significant difference in baseline TMD values suggesting that the difference in changes in TMD in the players tested during each season was not as a result of differing baseline TMD scores. Comparison of the baseline BRUMS scores and normative data for young athletes it is apparent that the scores for tension, depression, anger, vigour, fatigue and confusion are similar to the normative data given for young athletes in all the age groups (Terry and Lane, 2002).

Examination of the changes in individual mood states, across the first season, highlights that the change in TMD can be attributed to: increases in tension and anger with a decrease in vigour in the under 11s, 12s, 13s and 15s. The mean values for anger increased to levels just above one standard deviation of the normal values for young athletes in all age groups (Terry and Lane, 2002). Vigour decreased markedly to around two standard deviations below the population norms. The under 14s age group was the only exception to this as there was an increase in anger and decrease in vigour with no increase in tension. Previous work has shown both tension and anger to increase with increased training load (Morgan *et al.*, 1987; Morgan *et al.*, 1988; Murphy *et al.*, 1990; Raglin *et al.*, 1991). However these authors also showed a significant increase in fatigue, and depression has also been shown to increase significantly in athletes who have been diagnosed as over-trained. Some authors (Morgan *et al.*, 1987; Morgan *et al.*, 1988; Raglin *et al.*, 1991) suggest that it is probable that changes in fatigue and vigour are precursors of more serious mood disturbances such as depression or chronic anxiety which may occur when athletes develop overtraining syndrome. In season one of this study there was a significant drop in vigour but no significant increase in fatigue. It is possible that this was due to the physical stress placed on the subjects by competitive soccer being sufficient to reduce the subject's feelings of vigour but not high enough to result in the subjects feeling more fatigued (Morgan *et al.*, 1987). The work intensity and duration were not sufficient for the subjects to develop overtraining syndrome (Fry *et al.*, 1994). As outlined earlier the subjects tested in season two (restricted season) demonstrated no significant increase in TMD across the season. It is possible that limiting the number of competitive matches, young players are allowed to participate in, results in a reduction in the physical stimulus across a season thus explaining the absence of an increase in TMD (Gutmann *et al.*, 1984). This would appear to be supported by the results of the physiology chapter, in which aerobic fitness was maintained across the first season and decreased in the majority of the subjects tested across the second season. It is hypothesised that the failure to increase aerobic fitness might be as a result of the lack of progression in physical stimulus across a full soccer season. The results suggest that whilst there was a significant increase in TMD, in those subjects tested in season one, it was not of the magnitude of those reported in studies where aerobic capacity increased (Gutman *et al*, 1984). It would also suggest that the subjects were unlikely to have developed overtraining syndrome[1], in the first season, as there was no significant increase in depression or fatigue (Morgan, 1997).

The subjects tested in season two showed no significant increase in TMD, which would appear to suggest a reduction in the physical stimulus from participation in competitive soccer. Again this is supported by the results of the physiology chapter, which demonstrated a decrease in aerobic fitness across the restricted season.

When interpreting the results from the BRUMS it should be noted that mood can be affected not only by the physiological stress placed upon the body, but also by psychological stressors such as bereavement, relations with family and friends, and school work (Thayer, 1996). In an attempt to identify any life events that might have affected the TMD the modified Daily Analysis of Life Demands in Athletes (DALDA) (Ryder *et al.*, 2001) was used to identify both the sources and symptoms of stress. The results from the modified DALDA suggest that there was no significant change in the number of sources of stress experienced by the subjects across either season. Thus it is reasonable to assume that the changes, observed across season one, in TMD were as a result of the physical stress (training stimulus) placed on the subjects during the greater number of matches they participated in during the first season (Morgan, 1997). The DALDA did not highlight any rationale for the observed decrease in the under 11s TMD score across season two or the absence of increase in tension across season one in the under 14s age group. There is a lack of consensus as to the mechanisms responsible for mood changes in response to exercise (Berger and Molt, 2000). However environmental factors have been cited as a possible explanation (Berger and Molt, 2000). Baseline testing for the under 11 age group tested in season two, would have been the first

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testing session for the new cohort. It is possible that the elevated scores for tension and confusion were as a result of the stress involved in the initial exposure to the testing procedure

One limitation of the modified DALDA is that the scoring mechanism only allows the individual to comment upon how the source/symptom of stress compares with "normal". Consequently it fails to take into account the effects and significance of any age related stressors e.g. school/home work might be identified as being "worse than normal" in one age group with respect to the measurement time.

The application, of these findings, to the general population is reduced due to the relatively low number of questionnaires returned. The mean percentage returned was 46.1% with values ranging from 8% in the under 15s measured in season two, to 71% in the under 12s measured in season one, consequently analysis of the results collected in the under 15s age group was not included. The relatively low numbers of questionnaires returned also affected the statistical procedures employed with missing values again rendering the repeated measures ANOVA redundant. However, the additional missing values that occurred as a result of questionnaires not being returned prevented the examination of the correlation between the psychological and physiological findings.

Summary

Total mood disturbance increase significantly in all age groups tested across season one (unrestricted season) possibly as a result of the physical stress from participation in competitive soccer. There was no significant increase in TMD in the subjects tested across season two of the study. However it is possible that some individuals have demonstrated greater increases in TMD and could have potentially developed psychological symptoms of OTS but by analysing the mean group data these individuals may have been masked by those who showed no alteration in either TMD or the individual mood states. As such individual cases should be analysed in order to carryout a detailed analysis of the effect of participation in competitive soccer on mood profiles of elite youth team soccer players.

Conclusions

It can be concluded that participation over an unrestricted competitive soccer season results in an increase in TMD scores as a result of the physical load experienced in the soccer matches. When there is a restriction placed on the number of games children can participate in a season there is no alteration in the mood states of children.

Subjects may demonstrate individual mood profiles in response to the physical and mental stresses they are subjected to over a competitive soccer season, however these may be masked the group mean data.

Chapter 9: Immunology

9.1 Introduction

The review of literature for this study is situated in section 4 of the thesis.

Aims and Objectives

To investigate if participation in competitive soccer results in a change in salivary IgA concentration, and if limiting the number of competitive games young players are allowed to participate in affects any changes in salivary IgA concentration.

9.2 Methodology

The details of the immunological methodology adopted are outlined in section 6.5, 6.6 and 6.7 of this thesis.

Table 9.1 contains information regarding the subject numbers included in the immunology study. It is notable that whilst all the subjects recruited for the thesis were asked to give samples not all samples were included in the study due to sample contamination.

Table 9.1: Subject numbers in the immunology study

Age Group	*Season One*	*Season Two*
Under 11	9	NA
Under 12	8	NA
Under 13	7	NA
Under 14	9	NA
Under 15	15	NA

The results obtained from season one of the study indicated that it was not appropriate to continue the analysis with samples from season two (see section 9.3)

9.3 Immunology Results

This results section consists of the mean resting salivary IgA and cortisol levels, both expressed as a ratio to osmolality. The mean values for each age group are presented. Significance accepted when $p < 0.05$

Resting Salivary IgA Concentration

There was no significant change in the IgA/osmolality ratio across the first season in any of the age groups (Table 9.2). This could be as a result of the large standard deviations observed.

Table 9.2: Season One: IgA/Osmolality Ratio

Age	Week 0 Unit IgA per mOsmol Ratio (sd)	Week 42 (sd) Unit IgA per mOsmol Ratio (sd)
U11	618.88 (292.03)	1604.74 (2312.11)
U12	435.61 (324.53)	1097.51 (895.32)
U13	671.66 (453.94)	636.52 (349.23)
U14	202.57 (354.88)	202.14 (334.48)
U15	224.47 (311.24)	244.72 (308.92)

Cortisol

There was no significant change in the cortisol osmolality ratio across the first season in any of the age groups (Table 9.3) again possibly due to large standard deviations.

Table 9.3: Season One: Cortisol/Osmolality Ratio

Age	Week 0 Unit Cortisol per mOsmol Ratio (sd)	Week 42 Unit Cortisol per mOsmol Ratio (sd)
U11	23.56 (9.46)	24.29 (5.07)
U12	55.19 (78.25)	60.78 (73.02)
U13	21.66 (10.84)	34.49 (8.06)
U14	29.17 (17.11)	74.06 (73.80)
U15	30.70 (23.08)	64.02 (52.96)

Individual Responses

The results obtained for both resting salivary IgA and cortisol across each the whole season for the three subjects examined later as case studies are presented in Figures 9.1, 9.2, and 9.3. Unfortunately contaminated samples and problems with the viscosity of the samples resulting in high CVs meant that values were unavailable at some points across the season for each of the individuals

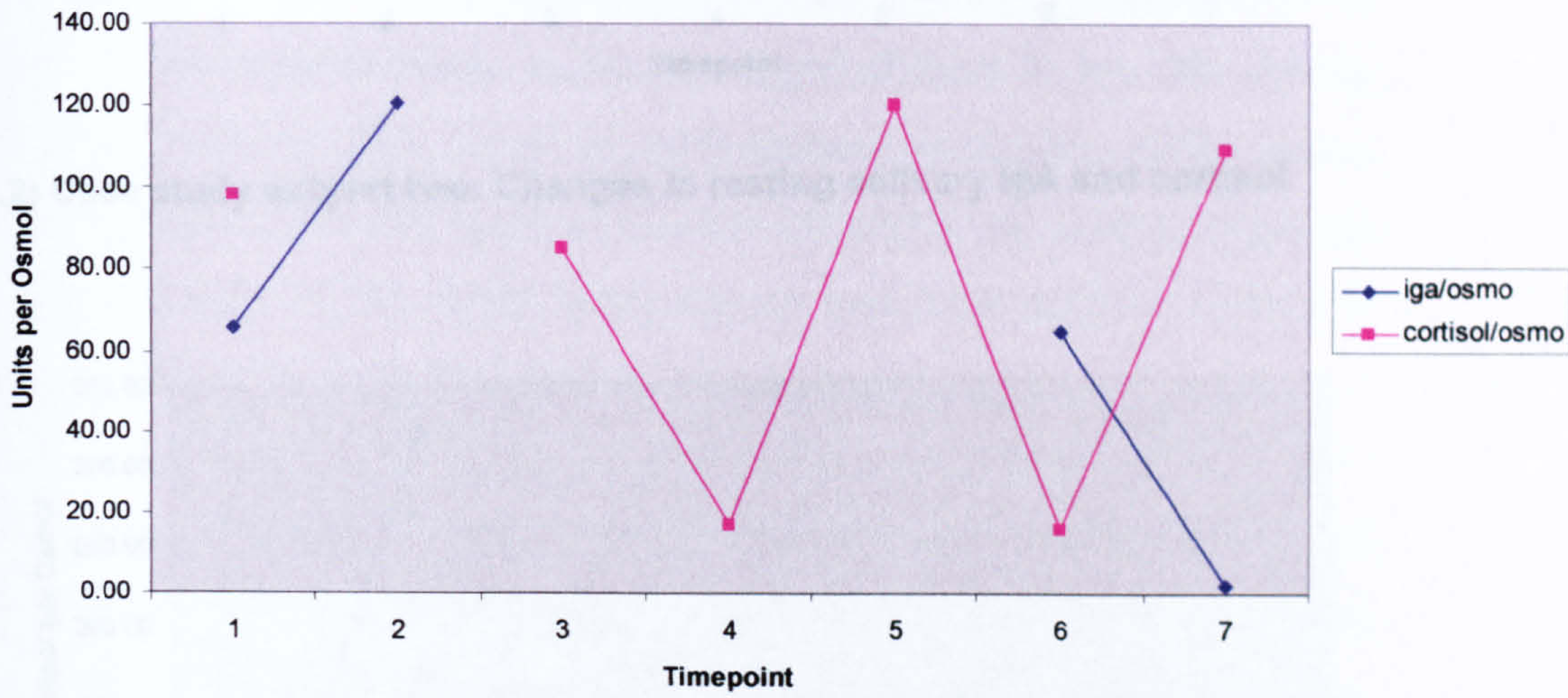

Figure 9.1 Case study subject one: Changes in resting salivary IgA and cortisol across season one

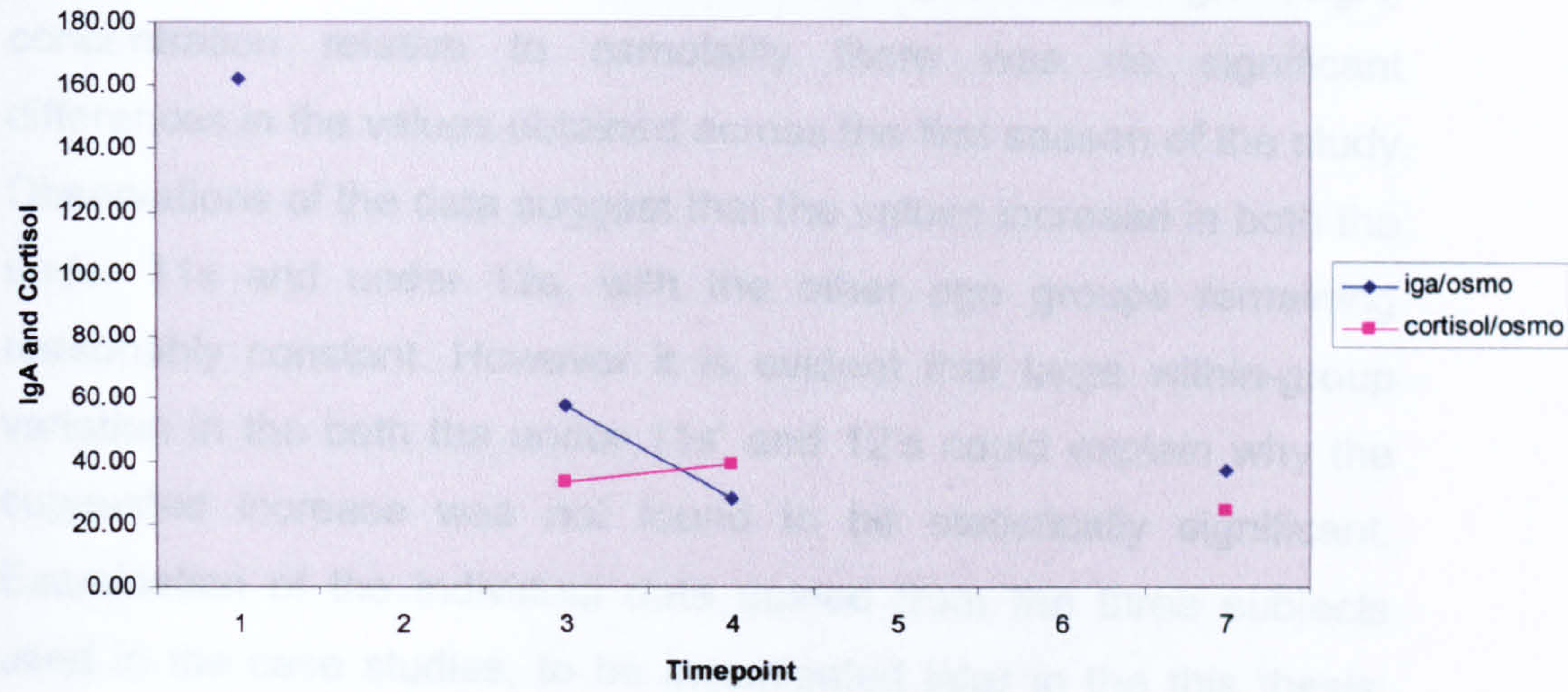

Figure 9.2: Case study subject two: Changes in resting salivary IgA and cortisol

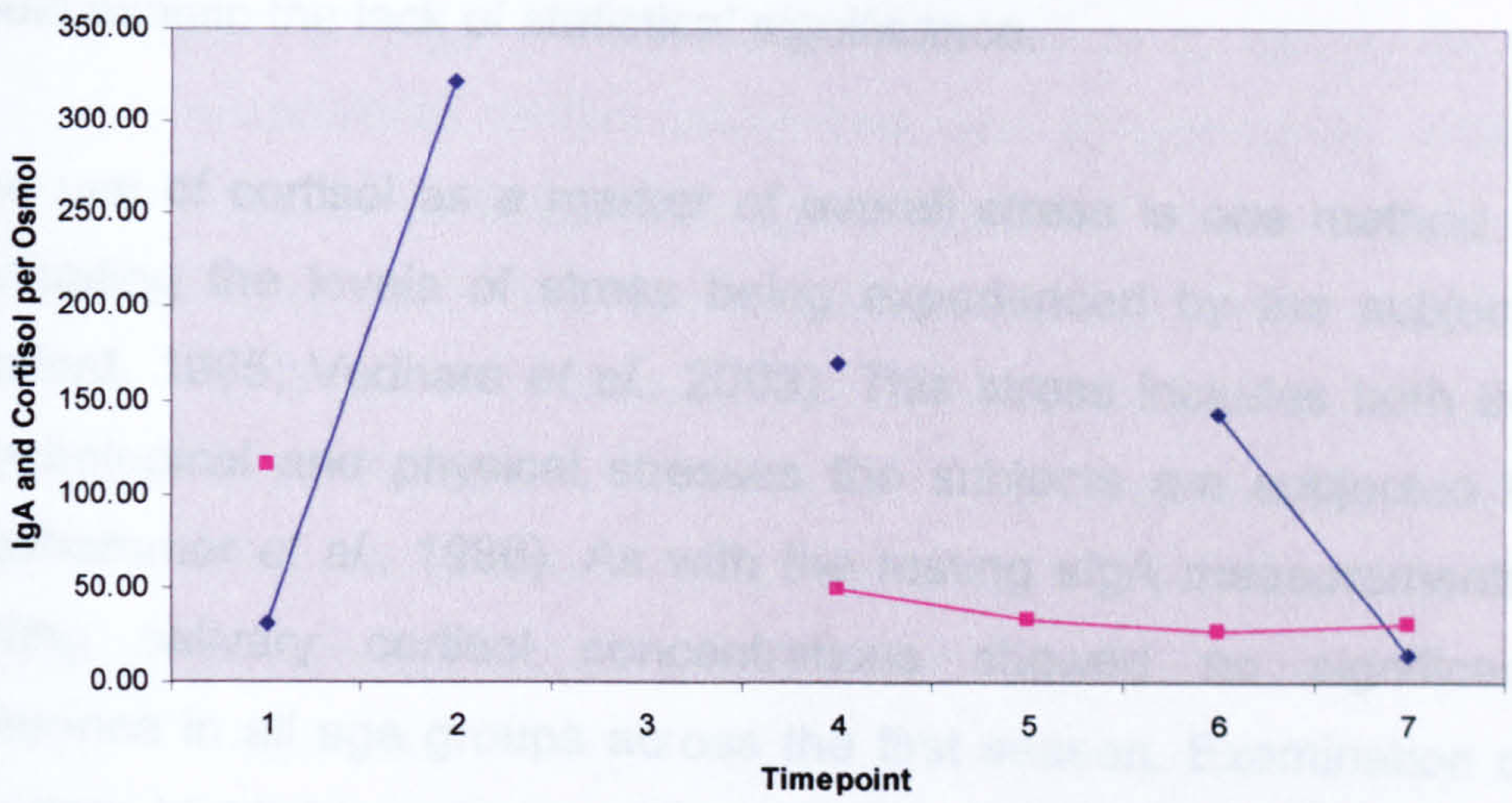

Figure 9.3: Case Study Subject Three: Changes in resting salivary IgA and cortisol

Each of the individual subject investigated demonstrated a large amount of inter-subject variability across the season for both the resting salivary IgA and cortisol values. A high level of intra-subject variability was also present.

9.4 Immunology Discussion

When examining the changes in resting salivary IgA (sIgA) concentration relative to osmolality there was no significant differences in the values obtained across the first season of the study. Observations of the data suggest that the values increase in both the under 11s and under 12s, with the other age groups remaining reasonably constant. However it is evident that large within-group variation in the both the under 11s' and 12's could explain why the suggested increase was not found to be statistically significant. Examination of the individual data gained from the three subjects used in the case studies, to be investigated later in the this thesis, demonstrates a high level of inter-subject variability with values ranging from 25 to 325 IgA's per osmol between two testing sessions. A combination of the large within-group and inter-subject variability could explain the lack of statistical significance.

The use of cortisol as a marker of overall stress is one method of evaluating the levels of stress being experienced by the subjects (Pollard, 1995; Vedhara *et al.*, 2003). This stress includes both the psychological and physical stresses the subjects are subjected to (Hellhammer *et al.*, 1986). As with the resting sIgA measurements, resting salivary cortisol concentrations showed no significant difference in all age groups across the first season. Examination of the data highlights a large within group variation and inter-subject variability, which is a factor contributing to the lack of statistical significance.

The large variation, present in both the IgA and cortisol measurements, could stem from a number of sources in the analyses as well as some inherent problems associated with the use of sIgA (Kugler *et al.*, 1993). Samples were run in triplicate using the following quality control process in order to minimize the errors with individual values obtained were accepted as valid when:

- the fit of the standard curve indicated an r-squared value > 0.95
- the mean optical density value gave an absorbance on the discriminating part of the curve
- the intra-sample coefficient variation value < 5.0% indicating consistency between the triplicate sample

If the above criteria were not met a different aliquot from the same individual/time was analysed again.

Large inter-individual variability is commonly associated with the use of salivary IgA and cortisol as illustrated by the difficulty in obtaining normative data for the concentration of sIgA (Kugler *et al.*, 1993). Examination of the data for this study demonstrates large, and occasionally very large differences between individuals. The concentration of sIgA present in human saliva is known to be inversely proportional to the saliva flow rate (Kugler *et al.*, 1993), which in turn can be dependent upon hydration status (Shannon, 1977). As such both sIgA and salivary cortisol were therefore expressed as a ratio with osmolality to reflect any changes in flow or hydration status. Another source of error in the sIgA measurements stems from the use of whole saliva. Whole saliva is defined as "the fluid obtained from the mouth by expectoration"(Malamud and Tabak, 1993). Whole saliva is produced by three paired major glands (parotid, submandibular and sublingual), which have independently controlled flow rates and each secreting individual concentrations of sIgA (Navazesh, 1993). The collection of whole saliva does not indicate the contribution of each of the individual glands, and therefore variation present in this study could be as a result of variation in the contribution of the individual glands (Malamud and Tabak, 1993).

One possibility for the lack of consistency, with regard to the effect of soccer participation on immune function, is that the individuals may differ in the capacity to cope with the physical demands of competitive soccer. What is a moderate intensity for one participant might be a high intensity for a second participant (Klentrou *et al.*, 2002). It is also possible that players had been participating in different amounts of competitive soccer and additional sports. However as outlined previously it was beyond the scope of this study to investigate the actually amounts of sports and activities played.

Another possible explanation for the results demonstrating a non-significant difference may stem from any change in an individual's response being masked by the mean group data as a result of the large inter-subject variability. It is possible to identify any individual changes by investigating what proportion of the subjects have values higher or lower than the group mean.

Problems were also encountered when carrying out the ELISA analysis. Some of the samples were contaminated with soft drinks by the subjects, analysis of these samples was not possible. Samples were also excluded when a high CV was obtained. In some cases, this was as a result of a very low dilution being required and the viscosity of the low dilution sample could have resulted in a high CV as a result of inconsistent dispensing (Navazesh, 1993). These missing values, and subsequently the differing number of subjects included in each study prevented an analysis of the relationships between the immunological, psychological and physiological data.

It is evident from both the literature reviewed and the results of this study, that there are a number of limitation associated with the use of resting salivary IgA and cortisol values. These have led to large within and between subject variability, and subsequently no significant results were observed. This would suggest that the use of resting salivary IgA and cortisol are not appropriate for the measurement of stress in young children, such as those observed in this study. Therefore it was decided to not include any further details of the resting salivary IgA and cortisol analysis.

Conclusion

There was large inter-subject variability of both the resting salivary IgA and cortisol values obtained in this study as a result of the inherent problems associated with collection of whole saliva. Techniques are available for the collection of saliva from each of the individual glands however using a Carlson-Crittenden collector for a parotid saliva sample or micropipette techniques used for the collection of submandibular and sublingual saliva (Navazesh, 1993). However the practical setting of this study requires a quick and accurate methods to be adopted, therefore the more complicated and time consuming alternatives, such as those listed above, are not suitable for this study. Consequently it was decided not to include any further details of the resting salivary IgA and cortisol measurements.

10. Case Study Approach

10.1 Introduction

This study has adopted a multidisciplinary approach to investigating changes in physical fitness in young soccer players. It has used physiological tests of fitness as well as psychological markers of mood state. Further more, qualitative measures of the sources and symptoms of stress combined with quantitative biochemical markers of stress were also measured.

Due to the nature of this experimental design, a number of missing values has meant that the statistical analysis of group data does not allow a detailed analysis of the relationship between the physical performance and markers of stress. These missing values were due to the inevitable problems associated with non-attendance at testing, non-completion of questionnaires or contaminated saliva samples.

In the case of this thesis, the case studies allow the examination of the relationship between the physiological and psychological results, thus allowing further investigation into the effectiveness and benefits of an inter-disciplinary approach to this research. However, for reasons outlined in chapter 9, the salivary IgA and cortisol method was considered not to be applicable for use in field studies with children and consequently are not included.

Aims

The aim of these case-studies is to: Investigate the effectiveness of an interdisciplinary approach to the monitoring of training status of individual young soccer players as a soccer season progresses.

Selection of Subjects

Subjects were selected on the basis of their initial aerobic fitness as indicated by their baseline performance on the multi-stage shuttle run (MSR). Three were selected retrospectively: one with a MSR performance close to the group mean value, the individual with the highest MSR performance and the individual with the lowest MSR performance. All subjects were tested in season one (unrestricted season) of the study.

Protocols for the data collection were those previously explained in the main methods section (Chapter 6).

10.2 Subject One

Subject one was selected as the individual with a baseline MSR performance closest to the group mean MSR performance in season one.

Personal Information - Subject One

Table 10.1: Baseline data for subject one

Parameter	Mean Group Baseline (sd)	Subject 1 Baseline Data
Age	11 Yrs 140 days (125 days)	11 Yrs 41Days
Height (cm)	146.3 (5.53)	136.1
Weight (kg)	35.60 (4.41)	30
Endomorphy	2.35 (0.59)	2.5
Mesomorphy	3.80 (0.83)	3.5
Ectomorphy	3.61 (0.96)	3.5
Ham/trunk (cm)	31.8 (4.02)	32
MSR (beep/level)	9.28 (1.10)	9.02
10 Metre sprint (secs)	2.02 (0.15)	2.25
Agility time (secs)	11.19 (0.73)	12.26

Subject one attended all testing sessions throughout season one, although at time point three he was suffering from a sore throat, general aches and pains and stomach ache. As such the subject was excused from the MSR test.

On the three weeks prior to testing at time point six, during season one, the subject sprained the fibular collateral ligament, in his right leg. This resulted in rest for seven days with appropriate treatment. Following this the club physiotherapist prescribed aerobic work performed on a cycle ergometer. The subject was considered fully fit in time for testing at time point six.

Results

Physiology

Over the season subject one demonstrated an improvement in performance in MSR performance (Fig 10.1), run through cones (Fig 10.2) and 10-metre sprint performance (Fig 10.3).

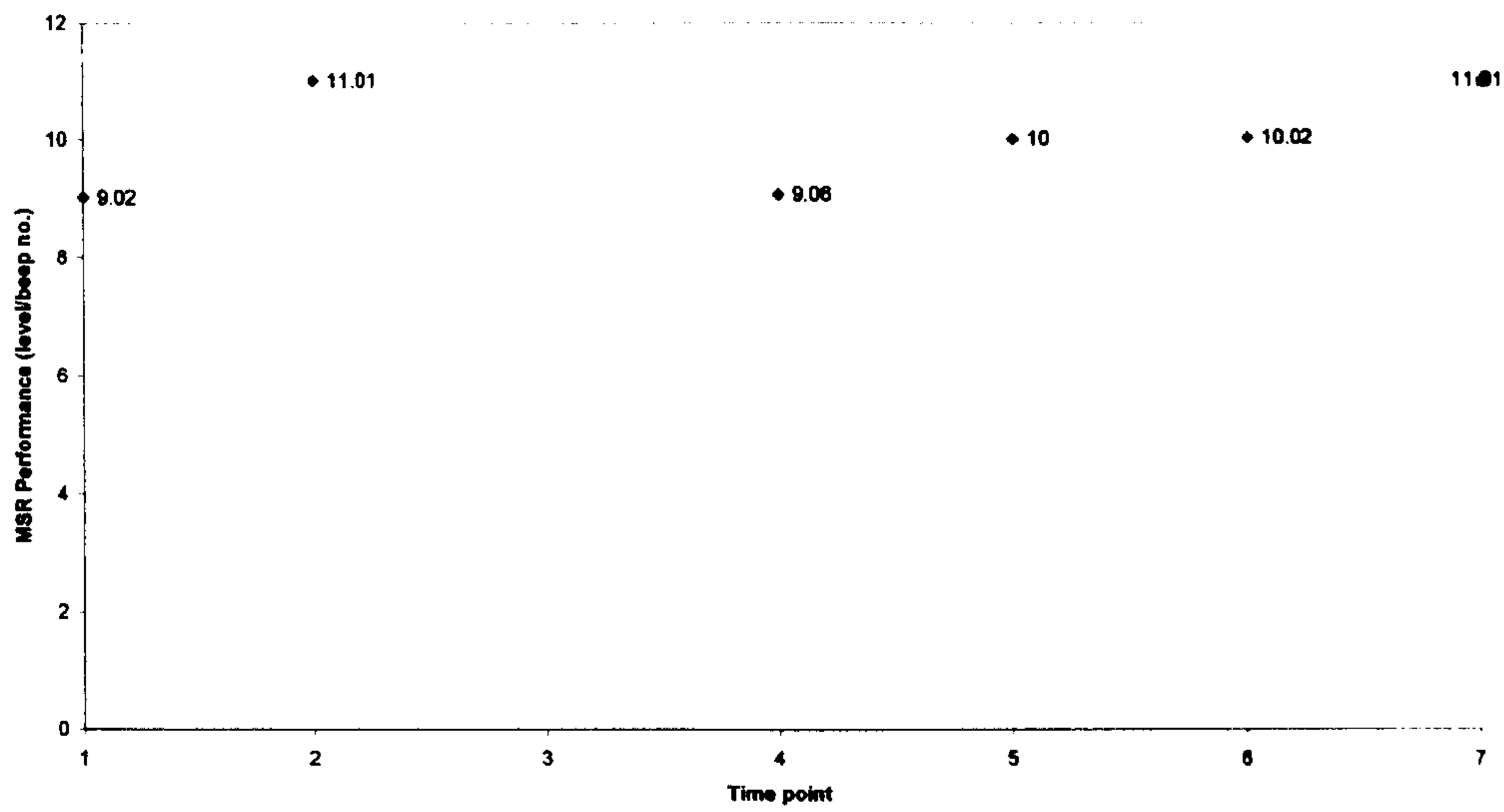

Figure 10.1 Case Study Subject one: Season one MSR performance changes

Despite subject one suffering from illness, which prevented him from training for two weeks and resulted in a subsequent decrease in performance between time points two and four, aerobic capacity increased across the season as indicated by an improvement in MSR performance. This increase could be as a result of the physical stimulus from participation in competitive soccer. The group mean LRC indicated that there was no increase in aerobic performance across the season and the LRC for subject one (0.15) was greater than that of the group mean (0.032). Time point two's data point was omitted as the subject failed to fulfil the criteria to demonstrate maximal effort.

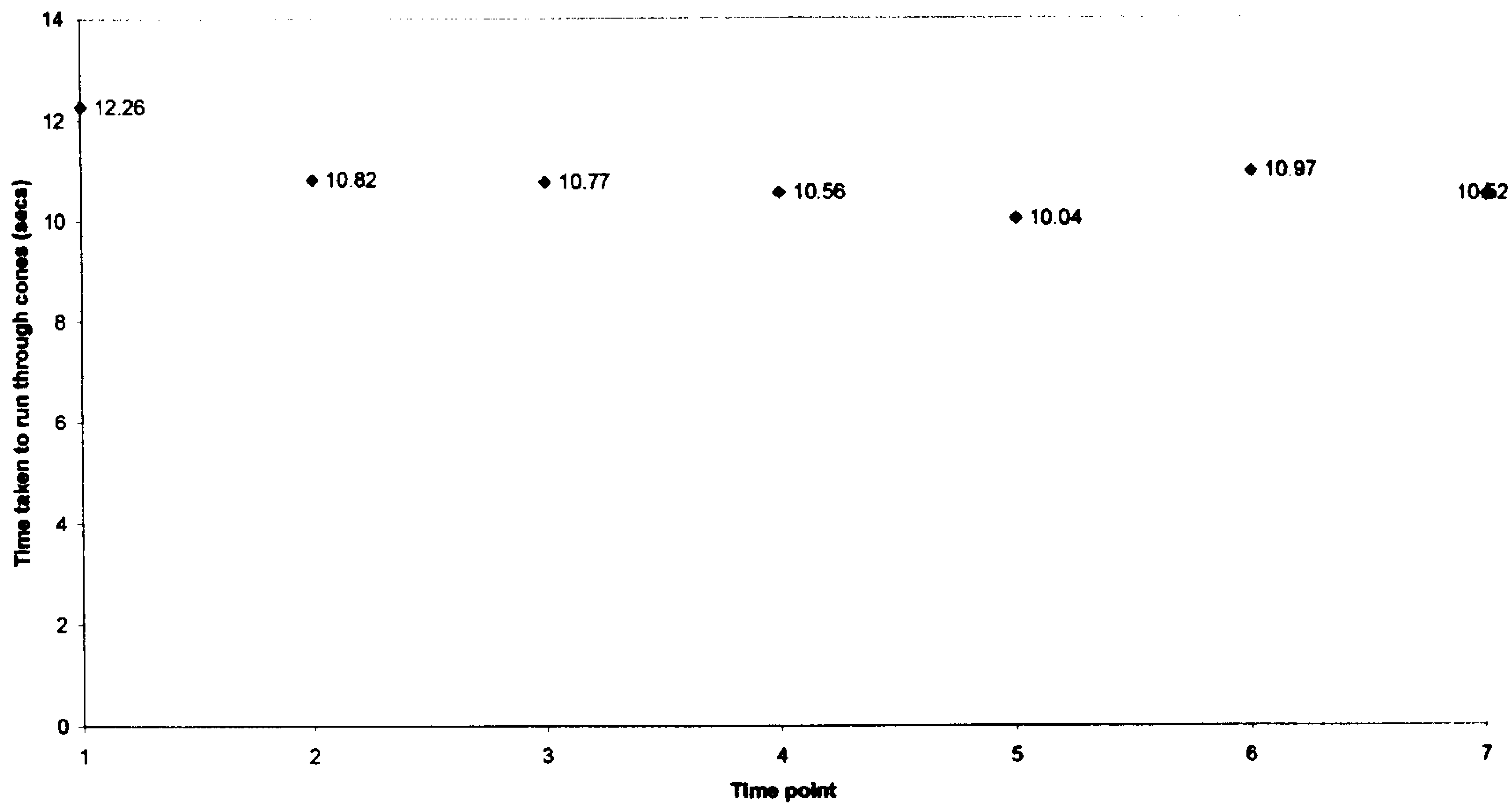

Figure 10.2 Case Study Subject One: Season one Agility run performance changes

The LRC calculated for subject one's agility run performance was -0.04 which suggests an improvement in performance as indicated by a reduced time taken to complete a run through cones. The LRC of -0.04 indicates that subject one improves faster than the mean group improvement (LRC = -0.01).

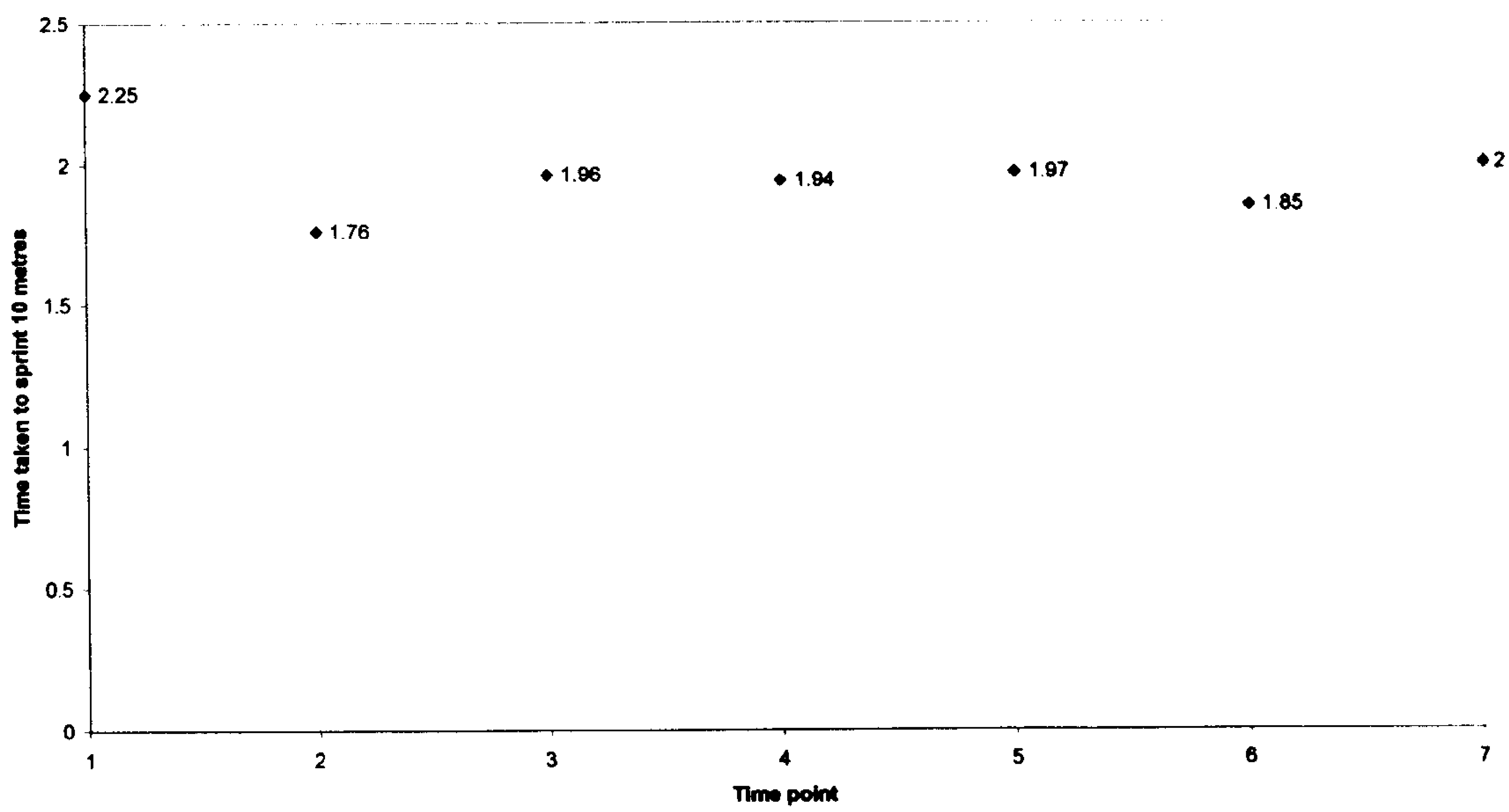

Figure 10.3: Case Study Subject One: Season one 10 metre sprint performance changes

The LRC calculated for subject one's 10 metre sprint performance was -0.004. This suggests an improvement in performance as indicated by a decrease in the time taken to sprint 10 metres. The LRC of -0.004 indicates that subject one improves faster than the mean group improvement (LRC = -0.002).

Psychology

Table 10.2 contains the psychological baseline data for subject one and compares this with the group mean baseline value:

Table 10.2: Baseline psychological data for subject one

Mood State	Mean Group Baseline data (SD)	Subject one Baseline data
TMD	95.90 (5.74)	105
Tension	0.30 (0.48)	0
Depression	0.00 (0.00)	0
Anger	0.44 (1.01)	0
Vigour	8.80 (3.52)	0
Fatigue	3.60 (3.31)	5
Confusion	0.40 (0.84)	0

Over the season subject one demonstrated a steady decrease in total mood disturbance (Fig 10.4)

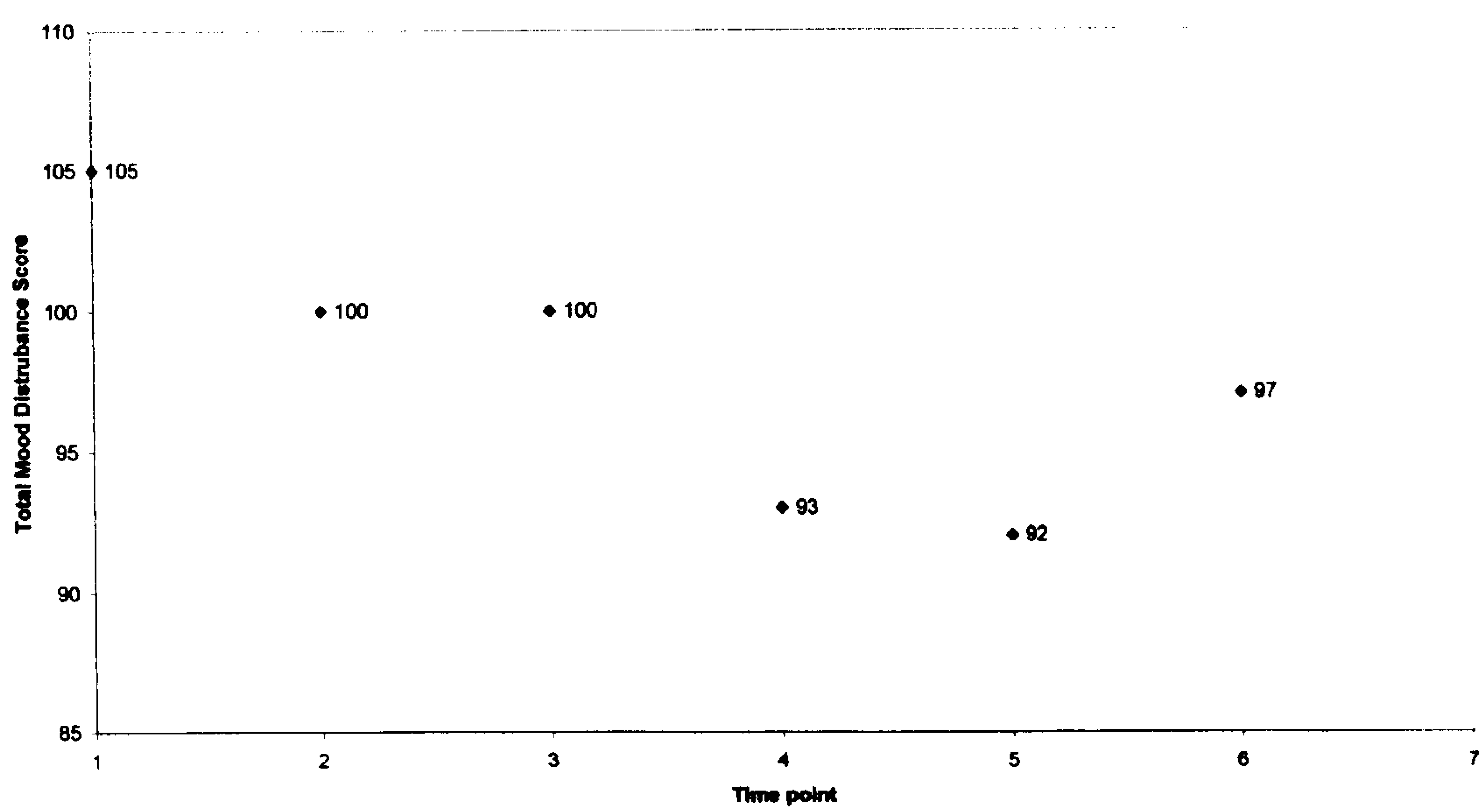

Figure 10.4 Case Study Subject 1: Season One Total Mood Disturbance (TMD) changes

There is a general decreases in TMD over the season, but with a slight increase from time point five to time point six. Subject one's baseline total mood disturbance score (TMD) was greater than the mean group TMD. This was due to a score of zero for vigour, much lower than the group mean score of 8.8 and a reasonably high score for fatigue (5) compared to the group mean score (3.6). There was a steady decrease in TMD across the season resulting in a TMD of 97 at time point seven. The decrease in TMD occurred primarily as a result of increasing vigour and decreasing fatigue levels, with a particularly large increase in vigour (and subsequent reduction in TMD) occurring at time point four. These changes in BRUMS results coincide with changes in the sources and symptoms of stress reported in the modified daily analysis of life demands in athletes (DALDA). At time point one, with the TMD being at its greatest (105) subject one was reporting the weather and relationships with friends and family as being worse than normal as well as reporting symptoms of illness. At time point four the decrease in TMD coincided with a reduction in both the sources and symptoms of stress. The results of the DALDA indicate that except for time point three when the subject was ill, the subject was coping with the physical demands from both training and competitive soccer suggesting the changes in TMD occurred as a result of the illness and the relationship with family and friends.

The scores for tension, depression, fatigue and confusion scores are all below the normative data published for young athletes and the scores for vigour and anger are similar to those given by Terry and Lane (2002). Whilst the BRUMS data gives a mood profile similar to the mental health model proposed by Morgan (1987). This also suggests that the subject was not being negatively affected by physical stress from participation in competitive soccer which is supported by the increase in aerobic capacity across the season.

Interrelations

When examining the usefulness of a holistic approach to this investigation it is evident that this case study has highlighted a number of benefits of an inter-disciplinary approach. Firstly the use of the DALDA for monitoring the sources and symptoms of stress has provided a rationalization for the observed changes in mood states. Both of the psychological questionnaires have also assisted in the identification of a possible explanation for the changes in MSR performance. A number of possible reasons could be cited for the decrease in MSR performance at time point three, however the DALDA questionnaire clearly identifies the subject as having a number of symptoms of illness and the subject also lists the illness as affecting his ability/desire to eat, perform sport and sleep properly. The TMD also then decrease sharply at time point four when the symptoms of illness are no longer remaining. Despite the TMD score being higher than the group mean at baseline the TMD is not sufficiently high to indicate the possible development of over training syndrome (Morgan, 1987) - this initial finding combined with the decrease in TMD at time point four suggests that the performance decrement is not as a result of OTS. This suggests that the decrease in performance is as a result of a de-training effect due to the weeks missed with ill health.

10.3 Subject Two

Subject two was selected as the individual with the highest baseline MSR performance.

Personal Information - Subject Two

Table 10.3: Baseline data for subject two

Parameter	Mean Group Baseline (sd)	Subject Two Baseline Data
Age	11 Yrs 140 days (125 days)	11 Yrs 232 days
Height (cm)	146.3 (5.53)	143.10
Weight (kg)	35.60 (4.41)	39
Endomorphy	2.35 (0.59)	2.0
Mesomorphy	3.80 (0.83)	4.0
Ectomorphy	3.61 (0.96)	3.5
Ham/trunk (cm)	31.8 (4.02)	33
MSR (beep/level)	9.28 (1.10)	11.04
10 Metre sprint (secs)	2.02 (0.15)	1.81
Agility time (secs)	11.19 (0.73)	10.79

Subject two failed to attend testing at time points two and six, although no reason was given for their absence. Coaches reported that he showed no signs of injury or illness at training sessions either prior to or immediately after these time points. Subject two missed no training sessions or matches due to injury or illness.

Results

Physiology

Over the season subject two's the calculated LRC values indicate MSR performance (Fig 10.5) remained constant, an improvement in agility run performance (Fig 10.6) and sprint performance deteriorated (Fig 10.7) across the season.

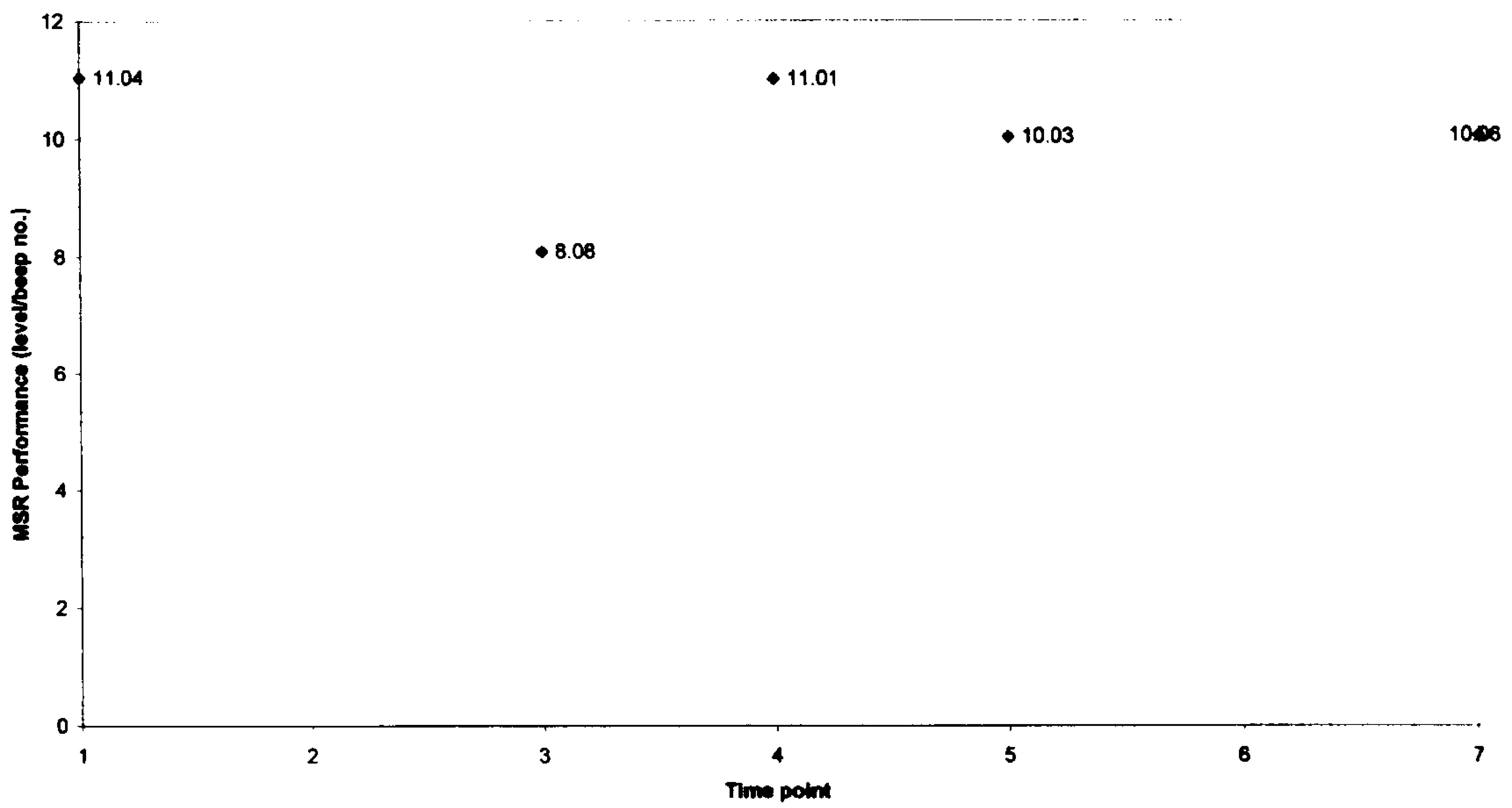

Figure 10.5: Case study subject two: Season one MSR Performance changes

There was a slight decrease in aerobic capacity, as indicated by the MSR performance. This was illustrated by a drop from level 11 beep 4 to level 10 beep 6. The individual RLC was 0.0 which confirms there was no significant change in aerobic capacity. This is in agreement with the mean group findings (0.03) which whilst slightly great than the individual score did not demonstrate a significant change. It is possible that this was due to the subject already demonstrating an aerobic capacity of a sufficient size that participation in competitive soccer would be unlikely to result in a further increase. A comparison with the changes in MSR performance in the previous subject would appear to support this as subject one's MSR performance peaked at level 11 beep 1.

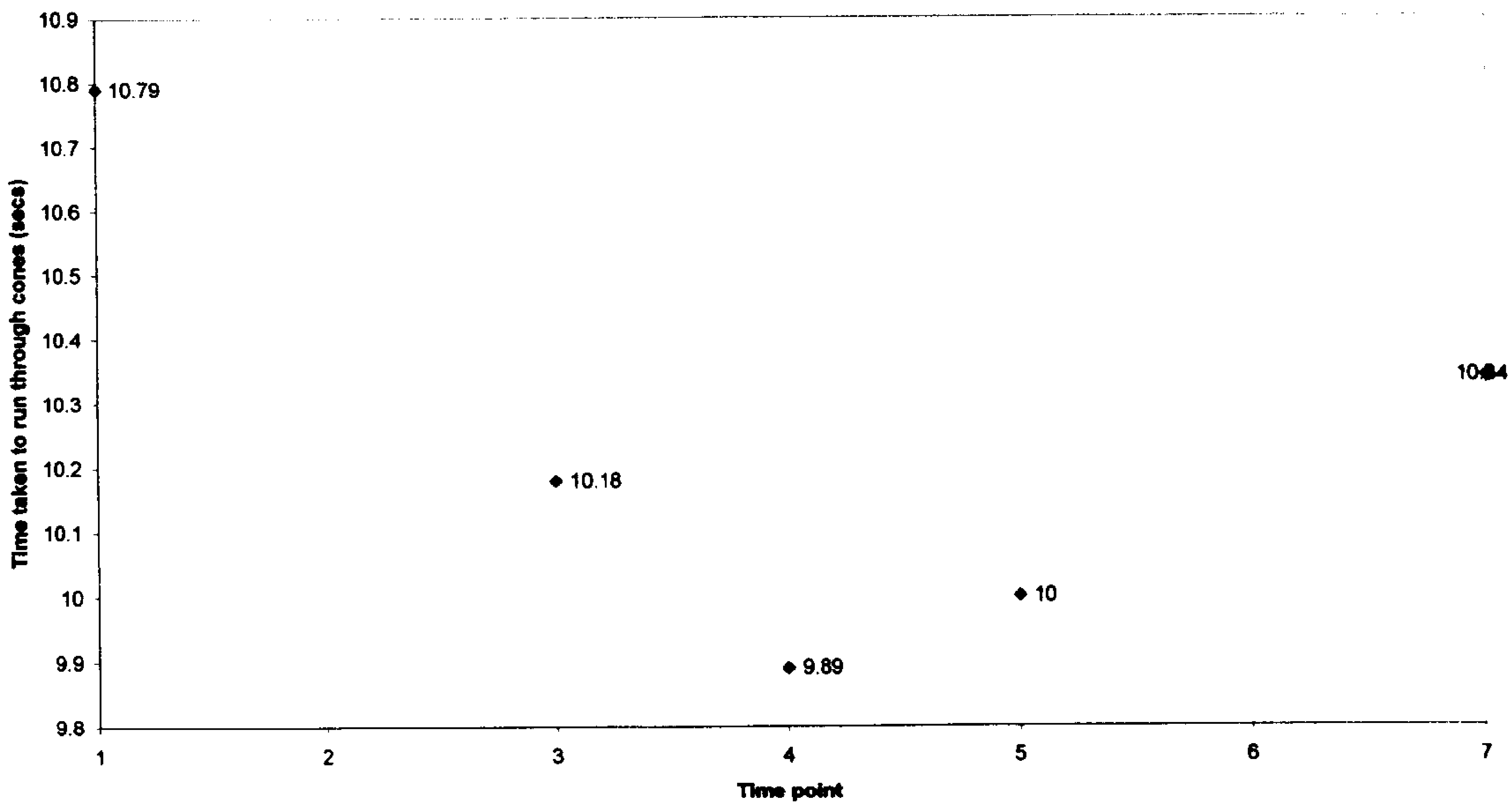

Figure 10.6: Case study subject two: Season one agility run performance

Subject two had a baseline agility run performance slightly quicker than the group mean. Over the season the time taken to complete the run through cones decreased from 10.79 seconds. to 10.34 seconds. The calculated LRC value indicates that subject two (-0.014) improved at a rate similar to that of the mean group improvement (-0.010).

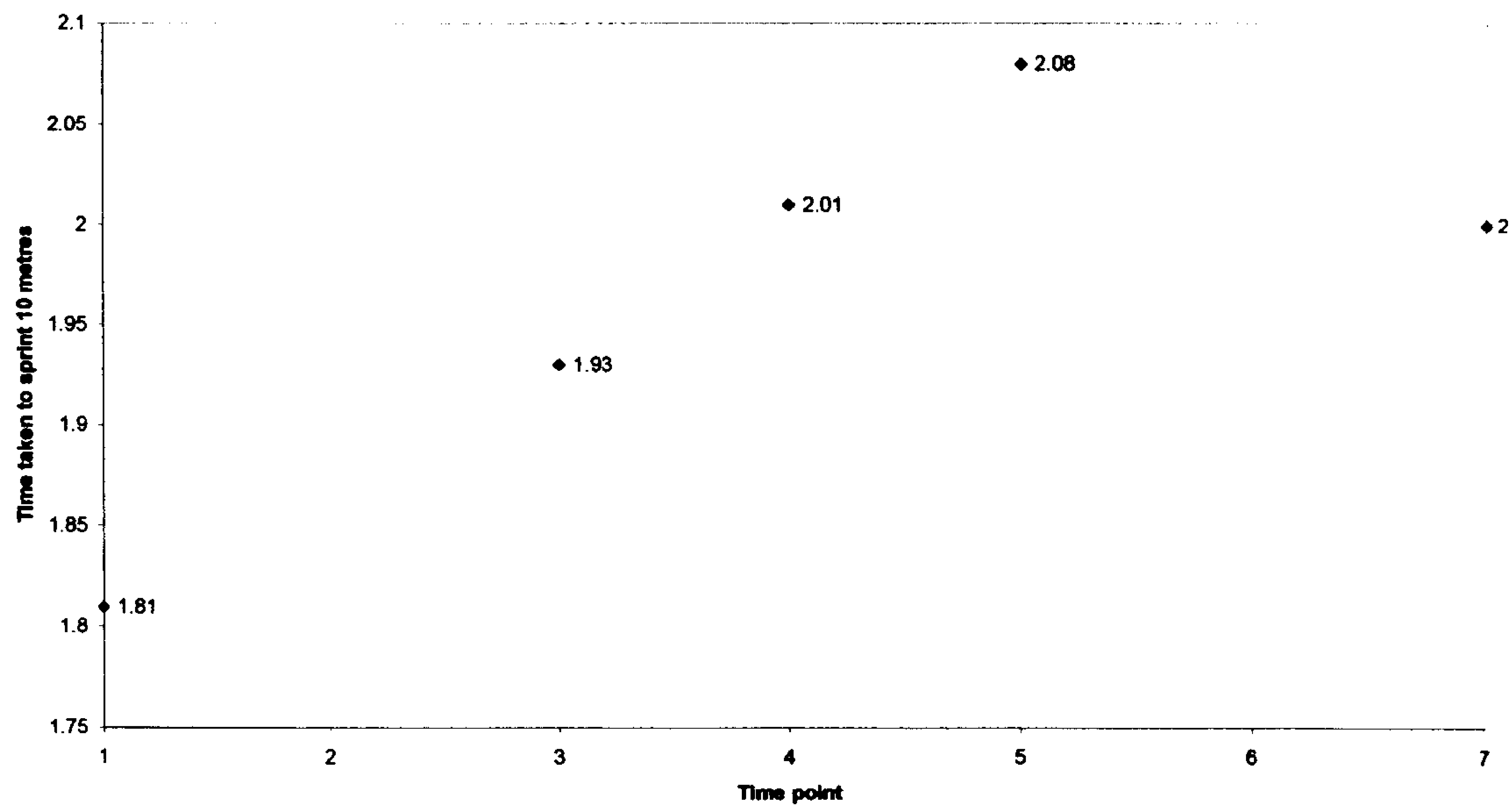

Figure 10.7: Case study subject two: Season one sprint performance

Subject two's 10 metre sprint time deteriorated across the season. Subject two had a baseline 10 metre sprint performance quicker than the group mean (1.81 seconds compared with 2.02 seconds). Over the season the time taken to complete the run through cones decreased from 1.81 seconds to 2.00 seconds. Whilst subject two showed a performance decrement across the season (LRC = 0.008), the group mean 10 metre sprint performance improves (LRC = -0.002). The decrease in 10 metre sprint performance could be as a result of an increase in weight across the season.

Psychology

Table 10.4 contains the psychological baseline data for the subject two and compares this with the group mean baseline value:

Table 10.4: Baseline psychological data for subject two

Mood State	Mean Group Baseline data (SD)	Subject two Baseline data
TMD	95.90 (5.74)	90
Tension	0.30 (0.48)	0
Depression	0.00 (0.00)	0
Anger	0.44 (1.01)	0
Vigour	8.80 (3.52)	12
Fatigue	3.60 (3.31)	2
Confusion	0.40 (0.84)	0

Over the season subject two demonstrated an initial increase followed by a steady decrease in TMD mood disturbance (Fig 10.8)

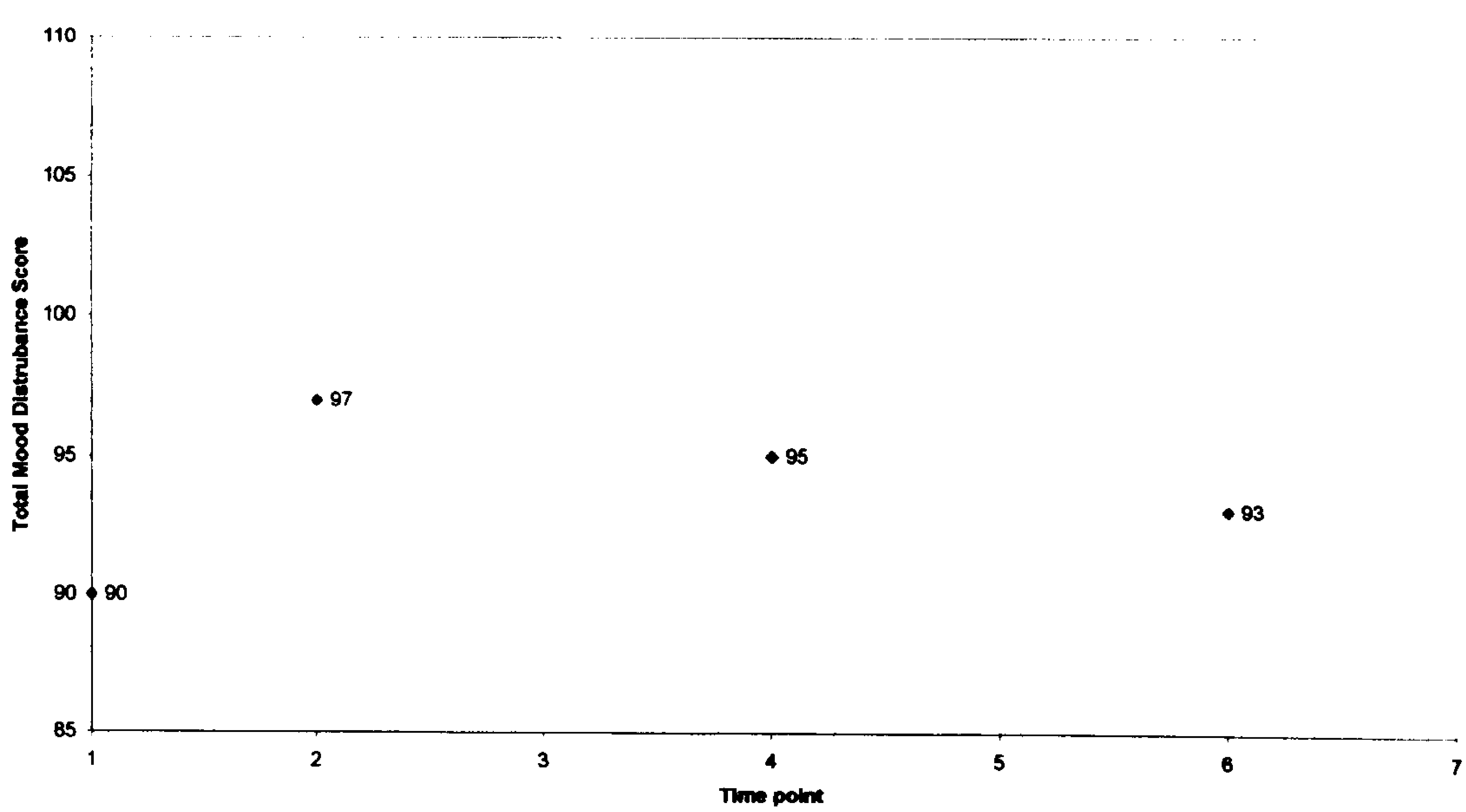

Figure 10.8 Case study subject two: Season one TMD changes

Subject two's baseline TMD score was less than the group mean. This difference is due to subject two having a higher score for vigour and a lower score for fatigue than the mean group score. The TMD increase from 90 to 97 between time points one and two, and then decreased steadily across the year. The changes in TMD were as a result of fluctuations in the score for vigour, with the other individual mood states remaining constant across the season. The scores for tension, depression, anger, fatigue and confusion are all below the normative data for young athletes (Terry and Lane, 2002). The score given for vigour was almost one standard deviation greater than the normative data, thus suggesting the individual was nearing the mental state associated with optimum performance (Morgan, 1997).

Examination of the sources and symptoms of stress indicate that at time point one the subject considered that he was getting less sleep than normal and listed this as a source of stress. This also resulted in tiredness and the amount of sleep he was obtaining was listed as symptoms of stress. Following this the no symptoms or sources of stress were identified at time points two and six, but the weather was indicated as being worse than normal at time point four. Throughout season one there was no indication from subject two that training or sport were creating higher stress levels than normal.

Interrelations

When examining the usefulness of a holistic approach to this investigation it is evident that this case study has highlighted some benefits of an inter-disciplinary approach. There was little change in the mood disturbances of the athlete, which indicated a good state of mental health across the season. This was supported by the results of the DALDA indicating few sources and symptoms of stress, the majority of which were reported at time point one.

There is an interesting drop in MSR performance at time point three (from level 11 to level 8). Unfortunately no heart rate data was available for this time point so it is not possible to identify if this was due to the subject not performing maximally. However the athlete neither reported nor had staff identify no signs or symptoms of stress, illness or injury, and the BRUMS score also indicated a healthy mental state. The vigour score was slightly lower than previous values but still equal to the normative data for young athletes, thus the subject was not demonstrating a psychological profile indicative of OTS (Morgan *et al.*, 1987). These factors combined with the immediate improvement in performance suggest that the decrease in performance was most likely to be as a result of a non-maximal effort, rather than illness, injury or the development of OTS.

10.4 Subject Three

Subject three was selected as the individual with the lowest baseline MSR performance.

Personal Information - Subject Three

Table 10.5: Baseline data for subject three

Parameter	Mean Group Baseline (sd)	Subject Three Baseline Data
Age	11 Yrs 140 days (125 days)	11 Yrs 6days
Height (cm)	146.3 (5.53)	141.6
Weight (kg)	35.60 (4.41)	37
Endomorphy	2.35 (0.59)	2.5
Mesomorphy	3.80 (0.83)	5
Ectomorphy	3.61 (0.96)	2.5
Ham/trunk (cm)	31.8 (4.02)	33
MSR (beep/level)	9.28 (1.10)	8.08
10 Metre sprint (secs)	2.02 (0.15)	2.16
Agility time (secs)	11.19 (0.73)	11.49

Subject three attended all testing sessions; however was excused MSR testing at time point six due to reports of nauseas. The coaches reported no symptoms or illness during the training sessions immediately prior to or after the testing session. The subject did not miss any training or matches due to illness or injury during the season, however immediately prior to time point four the subject did show early signs of Osgood Schlatters Disease - however this did not develop and the subject was not required to miss any training or matches.

Results

Physiology

Over the season the LRC values calculated suggested that subject three demonstrated an improvement in MSR performance (Fig 10.9), a decrement in both agility run performance (Fig 10.10) and 10 metres sprint performance (Fig 10.11).

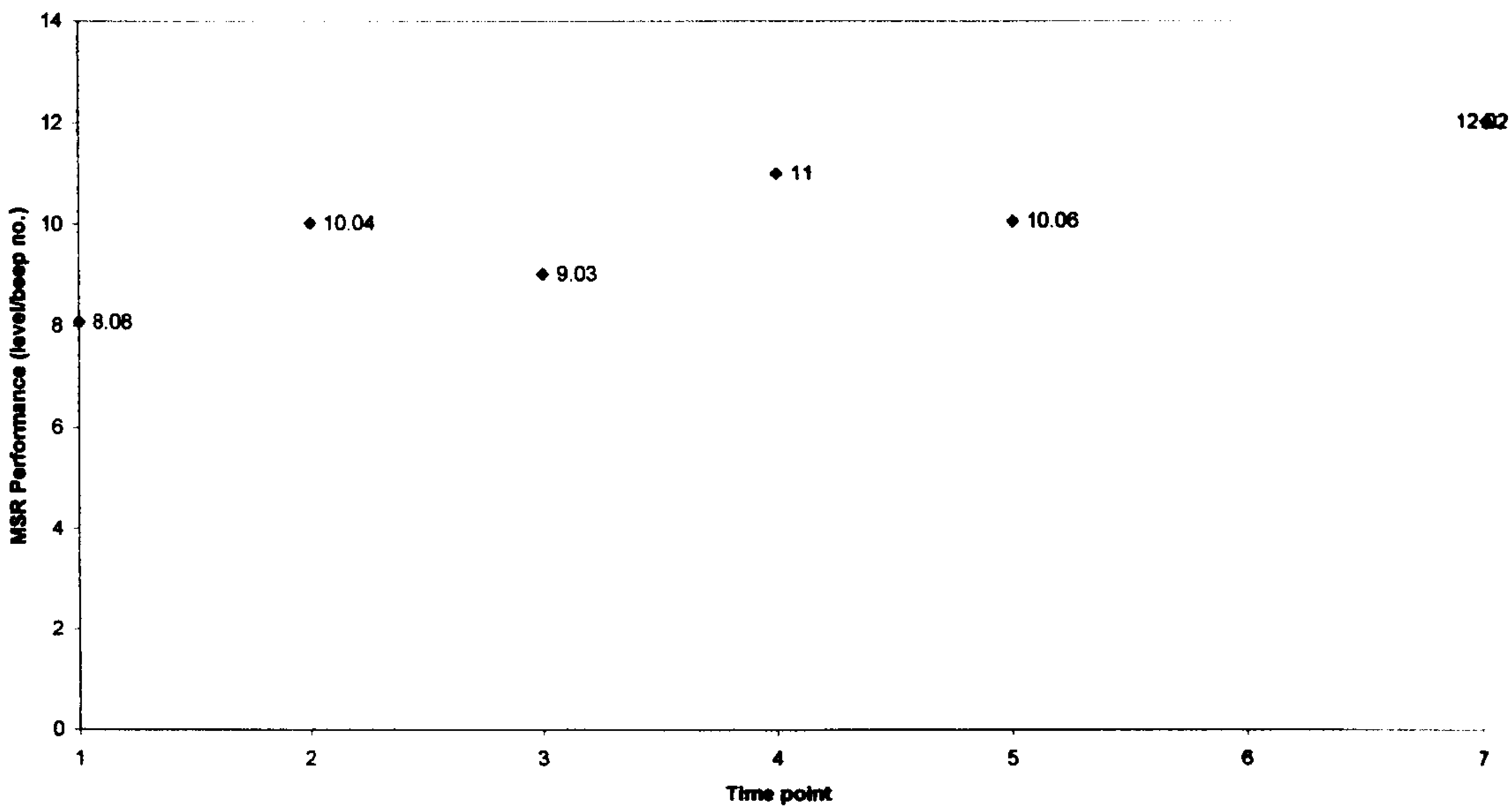

Figure 10.9 Case study subject 3: Season one MSR performance changes

Subject three's aerobic capacity increased across the season. The individual LRC of 0.11 is much greater than that of the group mean which indicated no change over the season (0.03). This could have been as a result of the subjects' relatively low aerobic capacity at the start of the season improving across the season as a result of the physical load of the competitive soccer.

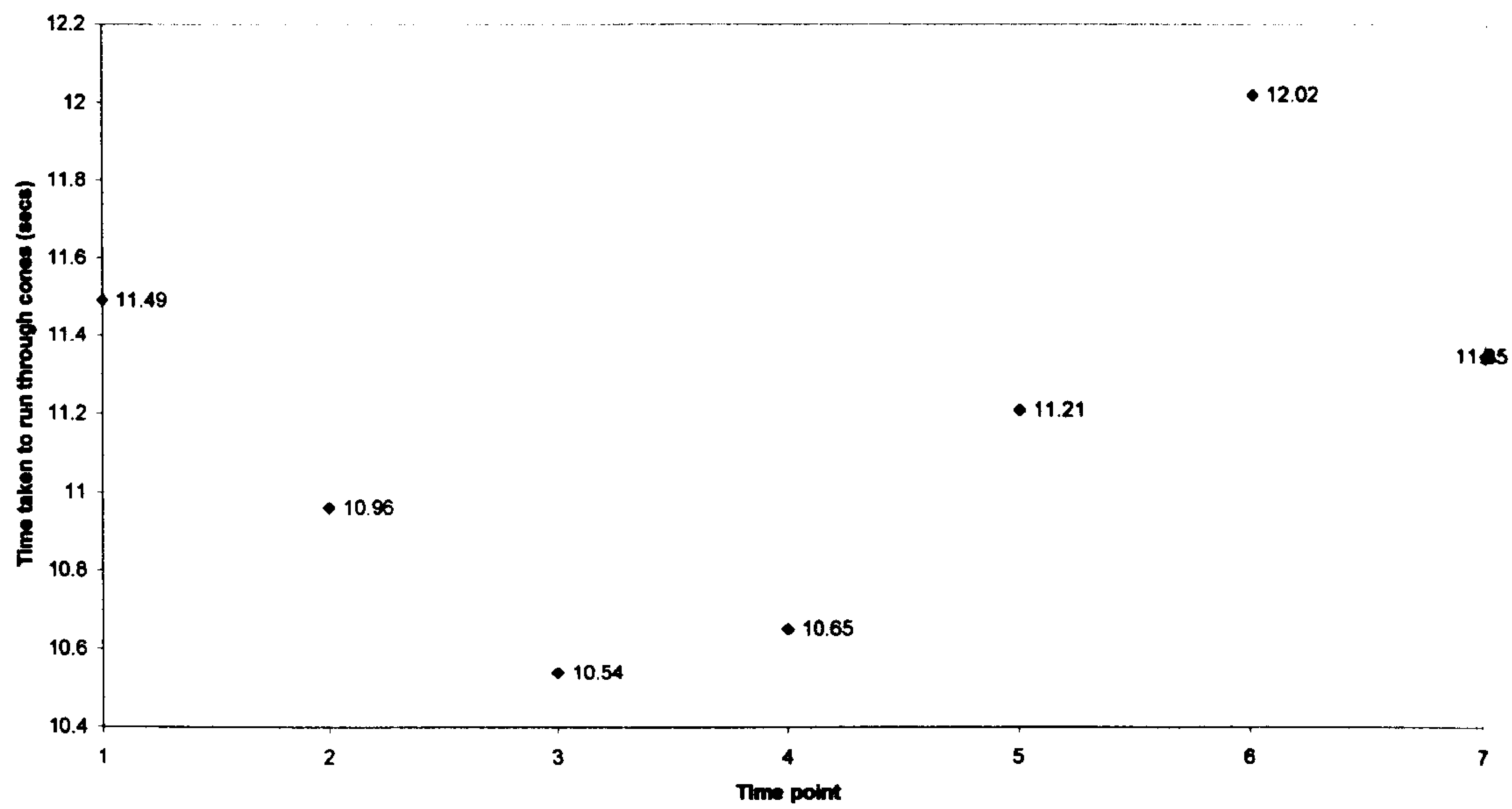

Figure 10.10 Case study subject 3: Season one agility run performance

The time taken for subject three to complete the run through cones was similar at time point one to the group mean baseline value (11.49 seconds compared with 11.19 seconds). The time taken to complete the run through cones decreased from 11.49 to 10.54 at time point three, but then increases steadily reaching 12.06 seconds at time point six followed by a final time of 11.19 seconds at time point seven. This gives a LRC of 0.64 indicating an increase in the time taken to complete the run through cones across the season. Early signs of Osgood Schlatters Disease (OSD) just after time point three might explain the slight increase in time taken to complete the agility run as the repeated changes in direction undertaken during the run might result in the subject suffering pain and it may also affect the stability of the knee resulting in a less efficient movement patter round the course. However OSD did not fully develop so it would not explain the continued increase in time taken to complete the run across the season. Examination of the change in height highlights a increase in height of 1.6 cm from time points three to four.

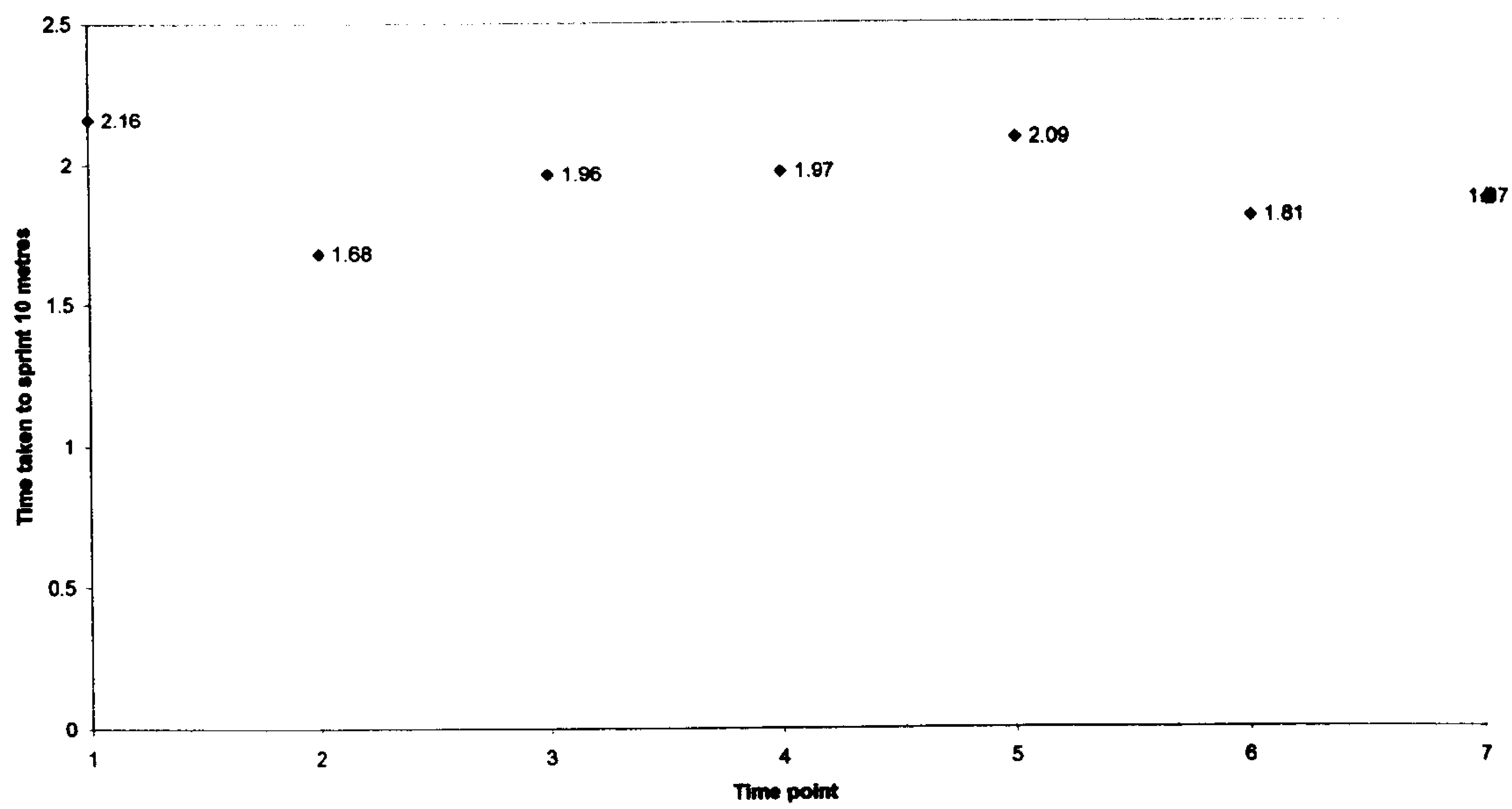

Figure 10.11 Case study subject three: Season one 10 metre sprint performance

The time taken for the subject three to complete the 10 metre sprint at time o (baseline) was 2.16 seconds, slightly slower than the group mean. Over the season the time taken to sprint 10 metres decreased from 2.16 seconds to 1.87 seconds, giving an LRC value of -0.004 which indicates a greater increase than the group mean.

Psychology

Table 10.6 contains the psychological baseline data for the subject three and compares this with the group mean baseline value:

Table 10.6: Baseline Psychological Data Subject Three

Mood State	Mean Group Baseline data (SD)	Subject three Baseline data
TMD	95.90 (5.74)	88
Tension	0.30 (0.48)	0
Depression	0.00 (0.00)	0
Anger	0.44 (1.01)	0
Vigour	8.80 (3.52)	12
Fatigue	3.60 (3.31)	0
Confusion	0.40 (0.84)	0

At the start of the season, subject three demonstrated a steady decrease in TMD. Then from time point four TMD increased and at time point seven was similar to the baseline value (Fig 10.12).

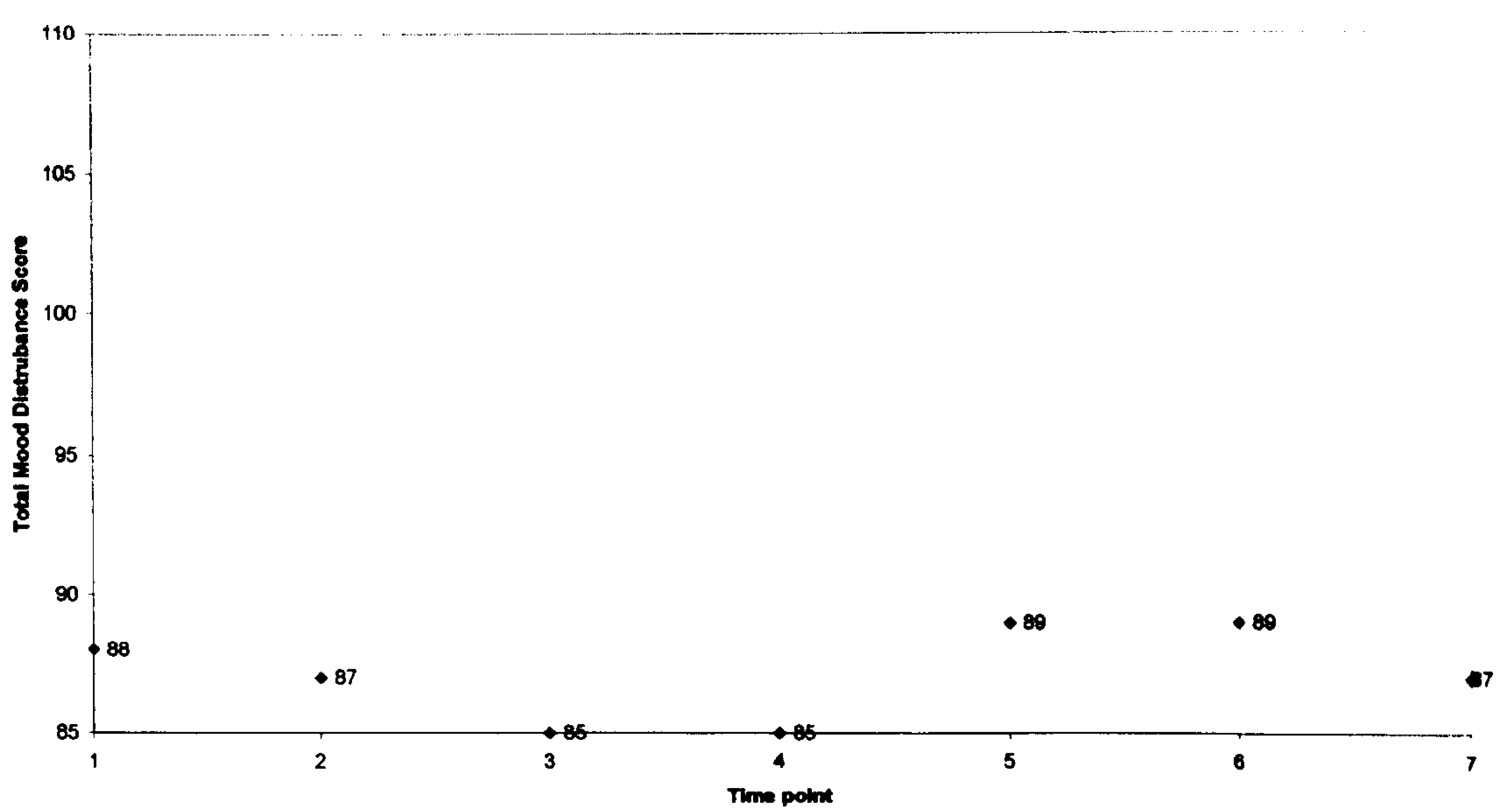

Figure 10.12: Case study subject 3: Season One Total Mood Disturbance (TMD) Changes

Subject three's baseline TMD score of 88 is lower than the group mean score of 96. This is due to higher value for vigour (12 compared with 8.8) and a zero rating for fatigue compared with 3.6 for the group mean. Subject three's TMD score remains reasonably constant across the year, fluctuating by no more than three points. The small fluctuations are as a result of small changes in vigour and at time points five and six fatigue has a score of one. This indicates that the subject maintained high levels of vigour throughout the season and suggests the neither the physical or psychological stress levels the individual was subjected to was sufficient to have a negative affect on the individuals TMD score. Examination of the individual mood states indicates that tension, depression, anger, fatigue and confusion are all below the normative data given for young athletes; vigour is almost one standard deviation greater than the normative data (Terry and Lane 2002). However as the TMD decrease at time points two and three the scores for vigour increase above 1 standard deviation greater than the normative data, thus indicating that the subject had a mood profile indicative of optimal physical performance (Morgan 1997).

Analysis of the sources and symptoms of stress as indicated by the DALDA indicate the source of stress most often reported as being worse than normal was the weather (at time points 1,5 and 7) with a slight knee injury being cited as a source of stress time point three, although the ratings for vigour were 15 at this time. The subject only indicated sport and training to be creating higher stress levels than normal at time point three, however this was as a result of frustration at a the knee injury preventing full participation in the sport. At no other point did the subject indicate sport and training to be creating higher stress levels than normal.

Interrelations

When examining the usefulness of a holistic approach to this investigation it is evident that this case study has highlighted some benefits of an inter-disciplinary approach. There was little change in the TMD across the season, and the subject maintained a mood profile suggestive of optimal physical performance, this was reflected in the DALDA results with the only symptoms of stress coming as a result of a slight knee injury (that did not limit physical performance).

Case Studies - Overall Summary

It is evident from these three case studies that there are a benefits from the inter-disciplinary approach adopted in field studies such as this. The use of psychological monitoring of mood and the sources and symptoms of stress has allowed further investigation into the possible explanations behind the physiological observations. This is specifically evident in case study two where there was an unexplained decrease in performance in MSR where technical problems with the HR monitor prevented a physiological assessment of work load. However analysis of the BRUMS and DALDA data highlighted that the individual reported no sources of symptoms of stress and that the BRUMS profile indicated as the negative mood states were still below the normative data for young athletes, and the vigour score was equivalent to the normative data the mental symptoms of OTS were evident. As such it suggests the subject failed to achieve maximal effort.

It is also interesting to observe that the individual with the lowest TMD score and the highest vigour score throughout the season demonstrated the biggest improvement in MSR performance across the season.

The case studies also highlights that when monitoring mood it is important to be able to identify the sources of stress that might be responsible for any changes in mood state indicated with the BRUMS questionnaire. This was evidence in all three case studies, and interestingly the only time that the sport participation was identified as a source of stress was during a period when the individual was suffering with illness. Identifying the sources of stress is an important part of monitoring mood states as there are a number of variables than can alter mood. As such results in studies, such as this, where the aim is to investigate the effect of sports participation on mood it is essential that the sources of stress that may have altered the mood profile be identified. Failure to do so could result in misinterpretation of results and in instances where the investigator or coach is attempting to use moods as a predictor of OTS misdiagnosis. This would have specific implications if the technique were used in an applied setting where a coach may miss-diagnose OTS and allow the athlete to take a prolonged rest from training which may result a decrement in performance.

Conclusions

When examining the effectiveness of an interdisciplinary approach to the monitoring of training status of young soccer players these case studies highlight that:

- The interpretation of the physiological results is aided by the inclusion of the psychological monitoring of mood states.
- The psychological monitoring of mood is supported by the use of the DALDA in order to identify the sources of stress that may have resulted in alterations in mood states.

11. General Conclusion

During this thesis, a multi-disciplinary approach was used to investigate the effect that participation in competitive soccer has, on the physical fitness, mood state profile, and immune function of elite young soccer players. The investigation encompassed two seasons: season one (S1) where there was no restriction on the number of games players could participate in and season two (S2) where the players were restricted to only 36 games across the season. Five separate experiments each were carried out in a different age group from under 11s through to the under 15s. The findings contradict the hypothesis in each of the disciplines. Performance in the multistage shuttle run (MSR) was maintained across the unrestricted season, and agility run and sprint performance both improved. In comparison MSR performance decreased across the restricted season with agility run and sprint performance being maintained. In the psychology chapter, total mood disturbance (TMD) increased significantly across the unrestricted season, but showed no significant change across the restricted season. The large variation in the immunological data gathered in the first season, made it largely unusable.

There were a number of limitations to overcome when developing the experimental design employed in this thesis. Ideally players would have been followed through both seasons, allowing a comparison of the same subjects in both conditions (eg S1, u11 vs S2, u12). However clubs release or transfer players at the end of each season, potentially resulting in a change of personnel. This would potentially render a year on year longitudinal comparison invalid. In order to overcome this, comparisons were made with aged matched cohorts of players from each season (eg S1, u11 vs S2, u11).

Injury and illness resulting in missing values occurring during the testing periods resulted in the repeated measures ANOVA being made redundant, in its usual form. This was over come by the calculation of individual linear regression coefficient (LRC) values for each subject (Altman, 1991). Group mean LRC values were compared to zero, to detect an change across a season, and then a comparison between the LRC values for each season was performed. The occurrence of missing values also prevented a statistical examination of the relationships between the disciplines. Consequently this chapter will attempt to examine the relationships between the findings of the three chapters.

The physiological study (Chapter 7) demonstrated that across the unrestricted season (S1) aerobic capacity was maintained and sprint and agility performance improved, as indicated by a decrease in the time taken to sprint 10-metres and complete a run through cones respectively. This is in accordance with the limited amount of literature available monitoring the fitness of adult soccer players across a full season which has shown aerobic fitness to be maintained across a season (Brady *et al.*,1997; Casajus, 2001). However there is, currently, no literature available on changes in either 10-metre sprint or agility run performance across a complete season. There is also no literature available investigating the effect of season long participation in soccer on the physical fitness of young children. However the studies examining the short-term effect of participation in simulated soccer on the fitness of young players would appear to support the findings of this study and showed no significant increase in aerobic capacity (Berg *et al.*, 1985; Mosher *et al.*, 1985).

Thus there was a difference in the observed rate of change between the seasons; with aerobic capacity being maintained and sprint and agility run performance improving across the unrestricted season compared to a decrease in aerobic capacity and only a maintenance of sprint and agility performance across the restricted season. This suggests that restricting the number of games young players are allowed to participate in results in a decrease in the physical stimulus required to maintain or improve physical fitness. The difference in findings could be as a result of a decreased physical stimulus. Limiting the number of games, without a subsequent increase in physical exertion during training sessions, could result in a reduction in the quantity of high intensity exercise children participate in. Removal of this training stimulus may result in the observed decrease in physical fitness (Hoffman, 2002). As stated previously, there is no literature available investigating the effect of season long participation in soccer on the physical fitness of young soccer players. There is also no literature available on the effect of limiting the participation of young children in competitive soccer.

The Brunel Mood Scale (BRUMS: (Terry *et al.,* 1999) was used in order to assess the physical stress experienced by the subjects. Mood profiling has been proposed as a systematic method of monitoring training load Gutman *et al.,* 1984; Morgan, 1997). Total mood disturbance (TMD) has been shown to change in a dose-response manner with training volume (Gutmann *et al.*, 1984; Morgan, 1997). The results from this experiment show appear to support the findings of the physiological study and suggest the physical stimulus experienced by the subjects in season one is greater than that of season two (Gutmann *et al.*, 1984; Morgan, 1997). There is a significant increase in TMD from week 0 to week 42, across the unrestricted season, in all observed age groups. This suggests an increase the physical stress being experienced by the subjects (Morgan *et al.*, 1988). The results, from the BRUMS, observed in season two also support the physiological findings. There was no significant change in TMD across season two in any of the age groups observed. These results suggest that the subjects are exposed a lesser physical stress in season one that season two. This supports the physiological findings that showed a decrease in aerobic capacity and no change in either sprint or agility performance as a result of a reduction in physical stimulus. This is supported by research investigating the relationship between mood states and training load. Gutmann *et al.,* (1984) and Morgan, (1997) both showed a TMD to increase in a dose-response manner, with respect to training load. Their work also showed that TMD decreased, to baseline levels, with a reduction in training load during a taper period.

It is possible that factors other than physical stress, could be responsible for any observed increase in physical stimulus (Berger and Molt, 2000). However the modified Daily Analysis of Life Demands in Athletes (Ryder *et al.*, 2001) was used to identify any additional sources of stress that might result in increases in TMD. These results indicated that there was no increase in the number of sources of stress identified in either season. As such it can be inferred that the increases, in TMD, observed across season one are as a result of an increase in the physical stress experienced by the subjects.

Previous research investigating changes in mood disturbance and physical fitness, has shown there to be an increase in TMD when the physical stimulus is sufficient to result in a positive adaptation e.g increase in or maintenance of fitness (Gutmann *et al.,* 1984; Hooper *et al.,* 1997). The results from season one suggest that whilst there was a significant increase in TMD, it was not of the magnitude of those observed in studies where aerobic capacity increases (Gutmann *et al.*, 1984). This again supports the findings of the physiological study and suggests that whilst there was a physical stimulus sufficient to maintain aerobic fitness, across season one, it was not of a magnitude sufficient to increase aerobic fitness. Whereas in season two, players were subjected to a lesser physiological stress which resulted in a decrease in aerobic fitness.

Findings from the immunology study do not support the results from the physiology and psychology study, and showed no significant change in either resting salivary IgA (sIgA) or cortisol. This can be attributed to the large inter- and intra-subject variability observed for both the sIgA and cortisol values. A number of quality control procedures were employed in this study to ensure errors were minimized whilst running the assay (pg 119). If these criteria were not met a different aliquot from the same individual/time was analysed again. Values were also expressed as a ratio with osmolality in order to accommodate variation as a result of hydration status (Blannin *et al.*, 1998). However large inter- and intra-subject variation is a limitation commonly associated with the use of saliva as a diagnostic tool (Kugler *et al.*, 1993). This is compounded by the collection of whole saliva not allowing the exact contribution of each of the individual glands and consequently affecting the secretion rates of both sIgA and cortisol (Navazesh, 1993). A further limitation of using this technique with young children was identified during the sample period, with a number of samples were contaminated with cordial and soft drinks, which rendered the sample redundant.

The results of the immunology study, question the validity of salivary IgA as a marker of immune function in children. Whilst some of the limitations associated with the collection of whole saliva can be overcome with specialised collectors (Navazesh, 1993), these are time consuming and can cause a level of discomfort for the subject. The limitations of using sIgA is illustrated by the by the difficulty in obtaining normative data for the concentration of sIgA in children (Kugler *et al.*, 1993). Blood borne markers of immune function have been demonstrated to give smaller variation, and are considered more accurate (Aardal-Eriksson *et al.*, 1998). However, ethical constraints associated with the sampling of blood from children prevented these techniques being used in this study.

Whilst it was not possible to carryout a statistical analysis of the relationship between the data in each discipline, evaluation of a series of three case studies allowed investigation into the effectiveness of an interdisciplinary approach to the monitoring of fitness of young soccer players. The case studies demonstrated that a multidisciplinary approach is beneficial in the monitoring of fitness in young soccer players. The case studies also highlight that when monitoring mood it is important to be able to identify the sources of stress that might be responsible for any changes in mood state.

Overall Summary

The physiological findings of this study are supported by the data from the BRUMS, and the DALDA results confirm that the changes observed in the BRUMS were as a result of the changes in physical stimulus. The immunological data failed to show any significant changes as a result of large inter and intra subject variability. It is therefore recommended that salivary IgA and cortisol are not suitable markers of immune function and stress in children.

The findings of this thesis show that restricting the number of games young children are allowed to participate in to 36 during a full season, reduces the physical stimulus the players experience. This can result in a reduction in their aerobic capacity as well as specific changes to both the anaerobic fitness component and the psychological component related to training and playing. It is also recommended that salivary IgA and cortisol are not suitable for use in studies with children.

In order to maintain the fitness profile, both physiological and psychological, that coaches ensure that players in their care have a sufficient physical stimulus that represents the game of football. In order to ensure overtraining does not occur, this stimulus should not be football per se but should be closely related to it but should also have important elements of cross training.

12. Future Directions:

There are a number of areas that should follow on from this research these include:

- *Short term* - The acute effects of participation in competitive soccer
- *Medium term* - The effects of season long interventions
- *Long Term* - Longitudinal research over periods greater than one season

12.1 Short term

It is clear during the review of literature that there is a requirement for the physiological load of competitive soccer on young participants to be quantified. This could be done via a combination of notational analysis and heart rate monitoring. It would also be of interest to evaluate how the work rate changes with subjects playing more competitive matches in a short period of time (eg three games per week).

This thesis attempted to evaluate the effect of participation in competitive soccer season on markers of stress. To date there is a lack of work investigating this area. This could be developed by investigating the effect of more competitive matches in a short period of time but also including a subjective rating of the "importance of the game" on the individuals stress response.

Injury is likely to have a profound psychological affect on soccer players (Price *et al.*, Unpublished) and therefore an investigation into the effect on mood profiles and cortisol levels (as quantitative markers of stress) would be useful.

There are a number of other aspects of the life of a young professional soccer player that might contribute to the overall stress level individuals experience and a series of experiments could observe the effect of each of these scenarios on the individual's stress level. These can include the pressure of individual matches; the uncertainty of being released by the club at the end of each season combined with the stress of awaiting a first professional contract as well as the previously mentioned effect of injury.

Both the areas outlined above, could be improved upon by investigating blood borne markers of stress such as cortisol. Bearing in mind the ethical issues surrounding the use of blood in experiments with children it is more likely that the work on resting salivary IgA and cortisol could be repeated with saliva being collected from the specific glands in an attempt to reduce the intra- and inter- subject variability observed in this study.

12.2 Medium Term

The review of literature has highlighted a paucity of research identifying the physiological profile of young soccer players. This thesis has carried out field assessment of young players ranging from under 11s through to under 15s across two full seasons. However there is a requirement for further laboratory assessment of the physiological profile of young soccer players. Included in this would be a measurement of anaerobic power and fatigue as well as an isokinetic measurement of strength to identify the potential imbalance between the strength of hamstring and quadriceps (Kearns *et al.*, 2001). This could be done as a cross sectional investigation to identify the age category where the imbalance potentially first appears, but then continued as longitudinal study in order to observe how the muscular strength of the individuals develops over time.

The findings of this thesis have highlighted that limiting the number of games results in a decrease in aerobic fitness, but no change in 10 metre sprint performance across a season. As such it is recommended that an investigation into the effect of sport specific training regime has on the fitness of young soccer players.

12.3 Long Term

This thesis involved a comparison of players of a similar age between two seasons. A longitudinal cohort study following a group of players from under 11 through to the first year of a professional contract, would allow the long term profiling of young players.

This could also involve the following of the original groups of players, including those who are released or choose to leave to play for alternative clubs.

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Appendix A

Modified Daily Analysis of Life Demands for Athletes

A COMPARISON OF THE UNDERSTANDING OF THE DAILY ANALYSIS OF LIFE DEMANDS IN ATHLETES (DALDA) AND A MODIFIED VERSION OF THE (DALDA).

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Introduction

The usage of subjective reporting of psychological states can indicate the initial onset of excessive stress in the body(Morgan, Brown et al. 1987). Silva (Silva 1990) claims that overtraining syndrome (OTS) results in *"detectable psychophysiological malfunctions and is characterised by easily observable changes in the athletes mental orientation and physical performance"*, and a number of methods of monitoring mood states have been proposed as useful in the diagnosis of OTS. When reviewing the literature on OTS is apparent that there is still debate as to the best physiological marker of OTS(Fry, Grove et al. 1994; Froehlich 1995; Hollander, Meyers et al. 1995; Armstrong and VanHeest 2002), however there would appear to be a general agreement that OTS is characterized by negative affective states such as anxiety, depression, fatigue, anger and a lack of self-confidence(Morgan, O'Connor et al. 1987; Hooper, MacKinnon et al. 1997). This led Hollander et al (Hollander, Meyers et al. 1995) to propose that the POMS scale can be used to screen young athletes for OTS. Indeed Hollander's postulation came about, partly, as a result of a series of work by Morgan and Colleagues who monitored swimmers over a ten-year period (Morgan, Brown et al. 1987; Morgan, Costill et al. 1988; Raglin, Morgan et al. 1990). This work, along with a collaborative study with Costill ((Costill, Flynn et al. 1988)) demonstrated that there was an 89% agreement between the psychological and physiological classifications of OTS. They also demonstrated that the mood disturbances increased in a dose response with increased training (Morgan, Brown et al. 1987; Morgan, Costill et al. 1988; O'Connor, Morgan et al. 1989; Raglin, Morgan et al. 1990). However, whilst the original POMS questionnaire has been shown to be a good marker of overtraining syndrome there have been questions raised over the unweilding nature of the 65 item format (Grove and Prapavessis 1992; Terry 2000), as such there have been a number of modified versions aimed at reducing the number of reported items and as such reducing the time for completion. The most commonly used example of this is the 42 item POMS proposed by Grove and Prapavessis 1992, this has also been shown to been a useful marker of OTS. However Terry and Lane (Terry, Lane et al. 1999) have published a further reduced POMS questionnaire, which were specifically designed for use with adolescents and has only 24 items. The short nature of this version also makes it particularly pertinent in an ecologically valid setting such as immediately prior to, or following competition(Terry, Lane et al. 1999).

Despite the quantity of evidence demonstrating the effectiveness of the POMS scale as a marker of training status, in studies where the training load is known and even controlled, problems may be encountered in studies where no such controls are possible and the investigator is attempting to investigate the incidence of OTS. This is because the physical and psychological stress from training and competition are not alone in affecting the subjective ratings of psychological state, but none of the above POMS scales allow subjects to record the sources of their stresses. As such observations as to the effect of training and competition may actually be due to some other source of stress within the athletes life. Whilst the effect of these other life stresses may also result in a reduction in performance, and the reactivity of an individual to a stressor is dependant upon the total number of stressors, which exist at any particular time (Fenz 1974). It would be a great deal of use to the coach if they were able to not only evaluate the psychological state of the athletes, but also to identify the sources of stress and thus be able to make the necessary adjustments to training or offer appropriate support to the athlete. Indeed as Rushall ((Rushall 1990)) explains:

"To understand an athlete's response to the specific stress of training, it is necessary to monitor the sources of stress outside of as well as in the sport."

At this present time the authors could only find 1 such questionnaire, The Daily Analysis Of Life Demands In Athletes (Dalda) (Rushall 1990)

Psychometric Issues

When devising a psychometric questionnaire there are a number of simple guidelines to follow. The following are some such rules, which the authors believe the original DALDA test violates.

- Questions and instructions should be unambiguous (Oppenheim 1973; Rust and Golombok 1992; Bourque and Fielder 1995; Fink 1995)
- Questions should be short and specific, rather than general in what they reference (Bourque and Fielder 1995)
- Questions should be less than 20 words long (Oppenheim 1973) and ideally between 10-12 words (Rust and Golombok 1992)
- Each item should ask only one question or make only 1 statement (Rust and Golombok 1992) as such "double-barrelled" that ask two questions at once should be avoided (Oppenheim 1973; Bourque and Fielder 1995; Fink 1995)
- All options have to be functioning as feasible responses (Rust and Golombok 1992)

The Questionnaire

The DALDA (Rushall 1990) is a self-report inventory examining sources of life stresses and symptoms of stress associated with athletic performance and an athlete's perceived lifestyle (Rushall 1990).

The questionnaire is divided into two sections; section A consists of nine sources of stress, and section B consists of 25 symptoms of stress. Each of these items is represented by a single word or short string of words (no greater than three). Definitions of these items are given separately. Individuals are asked to indicate whether each factor is currently: "a)-worse than normal", "b)-normal" or "c)-better than normal" (Rushall 1990).

When developing the test, Rushall carried out a number of vigorous procedures in order for the questionnaire to develop into its current format, the questionnaire was tested for readability with swimmers aged between 11 and 19 and it was concluded that the wording was sufficient that the wording of the items was sufficient to be understood by persons 11 years of age or older.

The following is an example of the format of question 2 on the original DALDA (Rushall 1990).

2. a b c Home-life

Definition given on following page:
Home-life: Have you had any arguments with your parents, brothers or sisters? Are you being asked to do too much around the house? How is your relationship with your wife/husband? Have their been any unusual happenings at home concerning your family?

It is obvious from this question that a number of the above guidelines for developing psychometric tests are being violated. Indeed this was demonstrated during studies by these authors, with children who used the inventory in the original format during a preliminary trial period identifying the following problems:

- Lengthy and ambiguous definitions that pose more than 1 question/statement
- The simple answers of worse than normal, normal or better than normal were not applicable in all cases
- With the definitions being on a separate page, not all the children read the definition and as a result misinterpreted the questions

Alterations and Adaptations

To redress this problem a modified version of the questionnaire has been devised with both the item and definition in a simplified format together, clearly identifying the meaning of each of the possible answers.

This study therefore firstly aimed to evaluate the understanding of both questionnaires and secondly to examine if the new format of the DALDA elicited any variation in the answers given.

The following is an example of how the above question was modified in an attempt to redress the given problems:

2: *Home-Life:* Think about your home life, and how well you have been getting on with your family over the last week then select A, B, or C.

A: My home life is worse than normal
B: My home life is the same as normal
C: My home life is better than normal

Methodology

Twenty-five boys aged 11 years old, were recruited from a local school. The boys were randomly chosen from a year cohort of mixed abilities.

Subjects were asked to complete both questionnaires (DALDA and Modified DALDA) and indicate if they understood each of the questions. Immediately following this the subjects were interviewed with regard to their understanding of each question. Both questionnaires and interviews were carried out on the same day.

Statistical analysis was carried out using the SPSS Version 10 package. A Wilcoxon Matched-Pairs Signed-Ranks Test was used to evaluate if there was a difference in the number of subjects understanding each of each of the questions. Following this, the answers obtained from each questionnaire were analysed using a One-Way ANOVA, with the questionnaire number as the factor, in order to investigate if the answers differed.

Results

The analysis showed that of the 34 questions, 11 of them had a significantly greater level of understanding (p = <0.005) in the modified version than the original. The statistical analysis also showed that only question 3 gave significantly different responses in the new format of the modified DALDA questionnaires.

Table 1: Table showing the P value for the Wilcoxon Matched-Pairs Signed-Ranks Tests, demonstrating any difference in the level of understanding of the Original DALDA and the Modified DALDA

Question Number	1	2	3	4	5	6	7	8	9
P-Value	1.00	1.00	0.083	0.157	0.317	0.025	1.00	0.000	0.157

	10	11	12	13	14	15	16	17	18
P-Value	1.000	0.000	0.317	0.317	0.000	0.157	0.157	0.014	0.157

	19	20	21	22	23	24	25	26	27
P-Value	0.025	0.008	0.317	0.002	1.00	0.157	0.000	0.083	0.317

	28	29	30	31	32	33	34
P-Value	0.317	0.000	0.157	0.083	0.014	1.00	1.00

Table 2. Table showing the P-Values for the One-Way ANOVA to investigate the difference in answers between the two questionnaires.

Question Number	1	2	3	4	5	6	7	8	9
P-Value	0.967	0.960	0.038	0.861	0.568	0.106	0.630	0.477	0.675

	10	11	12	13	14	15	16	17	18
P-Value	0.958	0.896	0.382	0.257	0.722	0.149	0.599	0.284	0.808

	19	20	21	22	23	24	25	26	27
P-Value	0.343	0.265	0.512	0.567	0.412	0.237	0.843	0.141	0.342

	28	29	30	31	32	33	34
P-Value	0.736	0.850	0.394	0.408	0.053	0.709	0.463

Discussion

As outlined above, the authors believe that the original format of the DALDA violates the following basic guidelines for psychometric questionnaires:

- Some of the questions are ambiguous
- The definitions can be lengthy and lack specificity
- Some of the definitions are "double-barrelled" in that they ask more than one question
- Some of the pre-determined answers of "normal", "worse than normal" and "better than normal" did not function as feasible responses.

Also by placing the definitions on a page resulted in some subjects not reading the full definition if they already consider that they had understood the question. Table? Outlines those items that demonstrated variations in understanding

The authors also considered that some of the terms and phrases used in the original DALDA were written in American English and as such could result in misinterpretation by a British subject population (Table 3).

Table 3 A table outlining which questions demonstrated a level of misunderstanding.

Number	6	8	11	14	17	19
Item	Climate	Health	Techniques	Supplementary Work	Irritability	Throat

Number	20	22	25	29	32
Item	Internal	Technique Strength	General Weakness	Congestion	Swellings

As such the wording items 6, 8, 14, and 32 were altered t remove any complicated words or American English. The definition of each item was also altered giving clearer, unambiguous statements

The format of the questionnaire was also altered to place the definitions with each individual item on the same page of the questionnaire; the format of the responses was also changed to clarify exactly what the answers were indicating. Inserting a short sentence of clarification with each answer did this.

The results of this would suggest that there was a significant increase in the number of questions understood, with all the above questions demonstrating an increased number of respondents exhibiting full understanding of the questions. Following the increased level of understanding demonstrated above, the authors needed to investigate whether these modifications resulted in different responses. As outlined in the results section only question 3 demonstrated a significantly different response .

Question 3 addressed the subject of school life, and with the change in answer indicated an improvement in the perception of their school life. This could be attributed to the questionnaires being carried out in a different subject, one the subject perceived as being easier or more enjoyable, thus resulting in an improved feeling.

Conclusions

In conclusion the modified Daily Analysis of Life Demands for Athlete's is significantly easier to understand but elicits the same response from children, when compared to the original DALDA.

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