CHICHESTER INSTITUTE OF HIGHER EDUCATION

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PSYCHOLOGICAL AND IMMUNOLOGICAL EFFECTS OF TRAINING AND MASSAGE IN AMATEUR BOXING

by Brian John Hemmings

Doctor of Philosophy

SPORT STUDIES

January 1998

This thesis has been completed as a requirement for a higher degree of the University of Southampton

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ABSTRACT

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A series of field based investigations were undertaken to establish the mood state and salivary immunoglobulin-A (S-IgA) response to different training loads in amateur boxing. Mood states were initially monitored via the Profile of Mood States (McNair, Lorr & Droppleman, 1971) and thereafter through the development of a boxing specific, shortened version. S-IgA was analysed through enzyme-linked immunosorbent assays. Results of the early investigations showed mood disturbances in fatigue, vigor, tension and anger with intensified training. Immunological data showed S-IgA to significantly decrease following interval training, with the principal factor in the suppression being a reduction in saliva flow rates. Boxers were seen to have unusually low saliva flow rates compared to sedentary individuals and this was linked to the weight-classified nature of the sport. There was no relationship found between psychological and immunological measures.

Subsequent investigations focused on the recovery process from amateur boxing. Massage was compared with control conditions as a post training recovery intervention. Results showed massage to induce psychological regeneration in the form of decreased perceptions of fatigue and increased recovery. Massage did not affect saliva flow rates post training. A final laboratory based investigation documented the effects of massage on psychological regeneration, physiological recovery and repeated amateur boxing performance on a boxing ergometer. Massage was seen to promote psychological regeneration, but did not affect blood lactate clearance or subsequent performance when compared with a no-massage condition.

It was concluded that amateur boxing training can result in detrimental psychological and immunological effects. It was argued that the role of passive recovery strategies in sport are still poorly understood and researched, but that preliminary support could be given to the vast amount of anecdotal evidence suggesting positive psychological effects of massage as a regeneration strategy. The use of massage for physiological recovery and as a performance enhancement modality was questioned.

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Chapter 1

Introduction

In modern competitive sport athletes must dedicate much time and effort in order to maximise performance. The desire to attain peak physical performance during competition necessitates rigorous physical conditioning and the adherence to heavy training schedules. Unfortunately, there is a wealth of evidence, both anecdotal and scientific, which indicates that intense training loads can have detrimental physiological and psychological effects.

The sport of amateur boxing has always demanded intense training for successful participation, with elite performers regularly training five to six times per day in heavy training periods. These punishing training loads, together with the strict dietary demands that boxing, as a weight governed sport imposes, has led to concerns over the stress experienced by amateur boxers during their training programmes.

In the scientific sports literature, the study of the negative effects of training is well established. In two classical reviews of this area, Fry, Morton and Keast (1991) and Kuipers and Keizer (1988) documented the occurrence of various psychological and physiological symptoms associated with conditions known as training stress, overtraining or staleness in athletes. These include hormonal changes such as the cortisol/testosterone ratio (O'Connor, Morgan, Raglin, Barksdale & Kalin, 1989), higher resting heart rates and blood pressure (Hackney, Pearman & Nowacki, 1990), loss of body weight, percentage body fat and muscle soreness (Callister, Callister, Fleck & Dudley, 1989) and an increased risk of injury (Fry, Morton & Keast, 1992). Whilst it is evident that many markers of training stress exist (Costill, Flynn & Kirwan, 1988), mood disturbances and the incidence of infections are the most prevalent and commonplace during amateur boxing training according to the National Coach of the English Amateur Boxing Association (Ian Irwin, personal communication, 1993).

Both these symptoms have also been identified in previous literature. For example, Morgan, Brown, Raglin, O'Connor and Ellickson (1987) demonstrated a dose-response relationship between global mood state and training volume in college swimmers, with increases in negative mood seen as the volume of training increased, and positive mood changes occurring as training volumes were reduced. Similar, though not always consistent, mood disturbances have been documented in a range of sports such as rowing (Cogan, Highlen, Petrie, Sherman & Simonsen, 1991) and running (Verde, Thomas & Shepherd, 1992). However, no published studies have followed the mood response in amateur boxing training.

Similarly, immune function and illness in athletes has generated much research. Fitzgerald (1988) has argued that infections may result in missed training and competitions, and could therefore be considered a performance limiting factor. Many studies have focused on the secretory antibody Immunoglobulin-A (S-IgA) response to exercise due to its role in providing defence against invading pathogens in the upper respiratory tract (MacKinnon & Jenkins, 1993). MacKinnon, Ginn and Seymour (1993a) have previously shown that a temporal relationship exists between a decrease in S-IgA concentrations and the onset of upper respiratory tract infections. The evidence arising from this research is equivocal, with the type, duration and intensity of exercise variables leading to conflicting results. For example, Tharp (1991) found S-IgA concentrations increased in basketball players over a season, whilst MacKinnon and Jenkins (1993) found S-IgA levels to decrease following kayaking interval training sessions. However, similar to the mood state sport literature, amateur boxing training has not been subjected to immunological research.

The benefits of conducting research into the training responses of amateur boxers are numerous. It would seem important to document the training responses specific to amateur boxing rather than to generalise inconclusive findings from other sports. Gauvin and Russell (1993) have proposed that sport specific studies are sometimes necessary to fully understand a problem in a specific context, or when research is undertaken within an applied setting. Here, the principle of sport specificity assumes that the assessment and monitoring of boxers should be undertaken if the adoption of subsequent interventions are to be effective. The subsequent knowledge of the type and level of mood disturbances may enable balancing of training programmes against the psychological well-being of individual boxers. Furthermore, the pattern of mood responses and any detrimental immunological effects would also provide the information needed to adopt appropriate intervention strategies to enhance recovery and hence help boxers cope with intense training loads.

At present, whilst much scientific endeavour has focused upon identifying the psychological and physiological markers of training stress, few studies exist which have employed interventions designed to combat the ill effects of training. One modality which may specifically counteract the negative effects of mood disturbances and decreased immune function is that of massage. Massage has been used in sport for many years purportedly serving many purposes such as speeding rehabilitation from soft tissue injury, increasing circulation and flexibility and decreasing muscle fatigue (Ylinen & Cash, 1988). However, empirical studies focusing on the physiological benefits of massage are far from conclusive, documenting equivocal results on the effects of massage on the circulatory, skeletal and muscular systems (Cafarelli & Flint, 1993). Equally, whilst many claims are made concerning the psychological benefits of massage, few scientific studies have documented such a relationship. Nevertheless, Weinberg, Jackson and Kolodny (1988) showed that a thirty minute massage produced positive acute mood responses in physical education students as measured by the Profile of Mood States (POMS, McNair, Lorr & Droppleman, 1971). Suitably, it may be that massage could be used to negate the effects of mood disturbances during training periods.

Similarly, massage treatment has been shown to lead to improved mucosal immune function in health research (Green & Green, 1987; Green, Green & Santoro, 1988; Groer, Dropplemann, Davis, Jolly, Boynton, Davis & Kay, 1994). Green and Green (1987) provided evidence that S-IgA concentrations increased as a result of twenty minutes back massage compared with no S-IgA increases in resting control conditions. This finding also suggests that massage could be used to counter any S-IgA suppression experienced as a result of heavy exercise.

Finally, another commonly held notion in sport is that massage can improve performance, especially where repeated performance is required (Ylinen & Cash, 1988). However, Callaghan (1993) has argued that the scientific massage literature in sport reveals little evidence to substantiate such claims. The effects of massage on performance have also been debated in a review by Cafarelli & Flint (1993). These authors have proposed that although previous sport massage research on physiological and psychological markers has been few in number and contradictory, performance effects should be easier to demonstrate and are perhaps more relevant to the sports performer. Nevertheless, at present the efficacy of massage as a regenerative technique between sporting performances remains unclear.

Therefore, the aim of this research was firstly to assess the mood state and S-IgA immune system response in amateur boxing training, and secondly to examine the effect of massage on these variables and on boxing performance.

Chapter 2

Review of Related Literature

Improvement in sporting performance is expected to be achieved through adaptation to a progressive increase in training stimulus. However, an abundance of scientific literature now exists which has identified overtraining and staleness as outcomes of negative adaptations to training (Fry et al., 1991). The notion that heavy training loads may have detrimental effects is not a new one, with observations of negative physical and mental states described by a cross-country skier as early as 1922 (O'Brien, 1991).

A wide range of physiological and psychological measures have been investigated as possible markers of negative training responses (Fry et al., 1991). However, to date it is evident that the majority of researchers have addressed physiological and psychological effects independently. Nevertheless, the need for multi/interdisciplinary research to investigate the combined psychophysiological effects of training stress has been highlighted by Weinberg (1990) and McCann (1995).

Interdisciplinary research requires a combination of knowledge and methods from more than one discipline, with an integration of information needed to develop an awareness of the interaction between disciplines (Burwitz, Moore & Wilkinson, 1992). The potential for interdisciplinary research in training stress has been demonstrated in several studies. For instance, Pyke, Craig and Norton (1988) showed that mood state changes reflected negative changes in physiological markers in a group of elite Australian cyclists. Similar findings were reported in separate articles by Morgan, Costill, Flynn, Raglin and O'Connor (1988) and Costill et al. (1988) who found performance decrements could be predicted to a high degree through the use of combined psychological and physiological assessments. Additionally, O'Connor et al. (1989) found mood state changes coincided with performance decrements and hormonal alterations in salivary cortisol in swimmers undergoing heavy training. The findings of these studies suggest the efficacy of an interdisciplinary approach. However, for the purpose of this review the psychological and immunological effects of training will be discussed separately, before considering possible interconnections between the disciplines.

A clear definition of terms is essential to review work in the training stress field. One difficulty encountered when reviewing the literature is a tendency for authors to use a variety of terms to describe similar concepts. Suitably, the first section of this review will introduce the terminology, definitions and descriptions commonly found in the literature, before establishing the identified psychological and physiological symptoms associated with negative adaptations to training. The second section of the review will focus more clearly on psychological monitoring of athletes during training loads via mood state profiling, whilst the third section will examine research on the incidence of infections in athletes and more specifically, the innate and acquired S-IgA immune system responses to training/exercise. The fourth section of the review assesses the use of massage as a regeneration/recovery strategy in sport, as well as discussing the potential of massage as a performance enhancement intervention. Finally, the last section will discuss the interdisciplinary issues concerning training, mood state, immune function and massage.

Section 1:

Terminology, Definitions and Symptoms of Training Stress

The deliberate strategy of exposing an athlete to high volume/high intensity training loads for performance enhancement has been labelled overload training (Fry et al., 1991). Overload training involves stressing an individual to provide a stimulus for adaptation and supercompensation (Wilmore & Costill, 1994). Silva (1990) has asserted that athletes can have positive or negative adaptations to training stress. Positive adaptations are seen as appropriate responses to both physical and psychological overloads imposed to initiate a training effect. Negative adaptations, on the other hand, are thought to occur when an imbalance exists between imposed training demands and psychological/physiological coping capacities (Silva, 1990).

A similar theme encompassing past research has been the absence of a uniform terminology to define the potentially negative effects of overload training (McCann, 1995). For instance, the term overtraining has been utilised by researchers in several ways. For example, some have used it to mean excessive training that results in performance decreases (Budgett, 1994), whilst others have used the same term to mean a deliberately planned and appropriate feature of training microcycles (Morgan et al., 1987).

Whilst other terminology such as overstressing, overreaching, overstrain, overfatigue, chronic fatigue syndrome and overtraining syndrome have also served to confuse matters, Fry et al. (1991) notes that sport scientists in the United States have historically labelled a state of failing adaptation to overload training as staleness, whereas European workers have used the term overtraining. Indeed, a review by a prominent North American researcher in excessive training stress lists overtraining as the cause or stimulus, with staleness as the consequence of too high training demands (Raglin, 1993).

In an attempt to redefine terms, Fry et al. (1991) suggested that overtraining be used when an individual has been stressed by training to the extent where he/she cannot perform at an optimum level. Additionally, overtraining syndrome and staleness were considered to be synonymous concepts, describing a state of chronically depressed performance. While

Silva (1990) has argued that the case for overtraining definitions lies in semantics, it is not the purpose of this review to present arguments for either definition. However, it is necessary to identify the terms used and provide the reader with some guidance on the different terms and associated concepts which appear in the literature. Suitably, for the purpose of this thesis, the definitions proposed by Fry et al. (1991) will provide the operational terms for maladaptive responses to training. In addition, for ease of purpose, the term training stress will be viewed as the negative effects of training without the necessary presence of an overtrained state.

The search for a reliable marker of overtraining has dominated past research (Collins, 1995). Since the risk of poor performance is likely to be greatly increased with overtraining, monitoring athletes for early warning signs has been the rationale behind most research (Hooper & MacKinnon, 1995). Fry et al. (1992) have documented the major symptoms of overtraining as indicated by their prevalence in the literature. In reviewing 336 previous studies, these authors divided the symptoms into twelve categories listed as performance related, sleep related, psychological, sensorimotor performance, cardiorespiratory function, musculoskeletal complaints, drinking/nutritional disorders, physical, physiological, hormonal, biochemical and infectious disease.

Similarly, Hackney et al. (1990) have listed the most common psychophysiological signs and symptoms of overtrained athletes. These can be seen in table 2.1.

Table 2.1.

Common Psychophysiological Symptoms of Overtrained Athletes (Hackney et al., 1990).

Apathy	Mood Changes
Lethargy	Elevated Resting Heart Rate
Appetite Loss	Elevated Resting Blood Pressure
Sleep Loss	Muscle Pain and Soreness
Performance Decline	Abnormal Resting Hormonal Profiles
Reduced Recovery	Heavy Feeling
Immune Deficiency	Weight Loss

Mood changes and immune deficiency are two common symptoms noted by Hackney et al. (1990) and both readily identify with, and offer monitoring opportunities for, potential problems encountered during amateur boxing training. Indeed both mood states and immune system indices are recognised as key areas for monitoring training stress and overtraining in athletes (Eichner, 1995; Fry et al.,1991; Hooper & MacKinnon, 1995; Kuipers, 1996).

Nevertheless, a prominent feature of overtraining is performance decrements. Callister et al. (1989) have suggested problems may exist in monitoring for overtraining in sports where performance is difficult to quantify, and the nature of amateur boxing performance seems to fit this category. Notwithstanding, though it may be difficult to readily identify overtraining in boxing because of this issue, it remains a worthwhile exercise to document the mood state and immune system response during amateur boxing training in order to assess the level of training stress and potential likelihood of overtraining occurring in boxing.

Finally, it must be recognised that monitoring athletes for markers of training stress and overtraining is not necessarily the most important research question facing sport science. The need for appropriate recovery and regeneration sessions has been identified as a crucial area of an optimal, well-balanced overload training programme (Budgett, 1994; Fry et al., 1991; Kuipers, 1996). Suitably, a relevant research question may be to address what constitutes an optimal recovery session, or as Crampton and Fox (1987) suggest, address the prevention of overtraining rather than simply monitoring for its occurrence or determining its cure.

Section 2:
Mood Profiling of Athletes During Training

Mood state profiling has been widely applied by sport psychology researchers. Applications have invariably utilised the POMS to study potential links between mood and other variables such as aerobic exercise (Berger, Owen & Frantsiek, 1993) and performance (Cockerill, Neville & Lyons, 1991). The POMS is a 65 item, 5 point adjective rating scale which measures six dimensions of subjective mood state: vigor, tension, anger, depression, fatigue and confusion and was originally developed for mental health research (McNair et al., 1971). Vigor is the one positive mood dimension, with the other five scales representing negative mood states. Internal consistencies within the six identified dimensions are near 0.90 or above, and construct and concurrent validity have also been reported (McNair et al., 1971).

Renger (1993) has maintained that POMS research has focused on two central issues of differentiation. Firstly, to distinguish between successful and non-successful athletes and secondly, to explore differences between athletes and non-athletes. Much research has attempted to verify Morgan's (1985) mental health model which states that "positive mental health enhances the likelihood of success in sport, whereas psychopathology is associated with a greater incidence of failure" (p.79). Morgan (1985) found that athletes, especially successful ones demonstrate an "ice-berg" profile when administered the POMS; that is, the negative mood states fall below the population average, and the positive mood state (vigor) falls one standard deviation above the population average.

More recent reviews by Rowley, Landers, Kyllo and Etnier (1995) and Terry (1995) have tended to support the idea that athletic populations show more positive mood profiles than the general population but challenge the idea that the "ice-berg" profile can discriminate between successful and less-successful athletes. Nevertheless, whilst the predictive validity of the POMS has been questioned (Rowley et al., 1995), its use in monitoring training loads in the identification of overtraining has been advocated by numerous authors (e.g. Eichner, 1995; Hooper & MacKinnon, 1995; Terry, 1995).

Psychometric monitoring has been performed in a multitude of sports in an attempt to detect mood disturbances occuring as a result of changes in training volume and intensity. Morgan et al. (1987) first reported that high training loads are consistently associated with mood disturbance. These researchers analysed mood state data from over 400 competitive swimmers across a ten year period and concluded that mood responses showed a dose-response relationship with training. Increases in training load resulted in mood disturbance, with reductions in training load resulting in alleviation of negative moods. Morgan et al. (1987) also provided some evidence of this dose-response relationship in a group of wrestlers, and subsequently advocated that the POMS could be used to monitor athletes for signs of overtraining.

Subsequent research examining the relationship between training and mood state has focused principally on swimming (Cox, Costill & Robergs, 1993; Morgan et al., 1988; O'Connor et al., 1989; O'Connor, Morgan & Raglin, 1991; Raglin, Koceja & Stager, 1990; Raglin, Morgan & O'Connor, 1991; Taylor, Rogers & Driver, 1997). However, changes in mood state accompanying varying training loads in endurance sports have also been reported in speed skating (Guttman, Pollock, Foster and Schmidt, 1984), running (Fry, Grove, Morton, Zeroni, Gaudieri & Keast, 1994; Verde et al., 1992; Wittig, Houmard & Costill, 1989), and rowing (Cogan et al., 1991; Raglin, Morgan & Luchsinger, 1990).

While these studies have consistently demonstrated various mood disturbances on the POMS subscales, there does not appear to be a uniform mood response to all types of sport training, with evidence of both individual differences and sport specific mood changes. However, if one assumes that the POMS can be used to monitor athletes for signs of overtraining, it is necessary to review the kinds of mood disturbances found and discuss which are common mood responses to training and conversely, the profiles which an overtrained athlete may exhibit.

Firstly, the POMS factors of vigor and fatigue consistently display the largest changes in response to training volumes compared to the other mood factors. The vigor scale is defined by adjectives suggesting a mood of vigorousness, ebullience and high energy and is negatively related to the other POMS factors, whilst the fatigue scale represents a mood of weariness, inertia and low energy level (McNair et al., 1971). Increases in fatigue and decreases in vigor, of varying degrees, have been shown across a variety of sports including speed skating (Guttman et al., 1984), swimming (O'Connor et al., 1989) and running (Fry et al., 1994). Changes have also been noted over time in professional ballet dancers (Leiderbach, Gleim & Nicholas, 1992). Nevertheless, it remains unclear whether adverse changes in vigor and fatigue without other mood disturbances necessarily indicate the possibility of overtraining. Raglin (1993) has suggested that the vigor and fatigue mood states both contain a somatic component and changes in these moods during training may indicate a "normal" response (p. 847). Changes in vigor and fatigue have been noted in swimmers not diagnosed as overtrained (Morgan et al., 1987; 1988; Raglin et al., 1991) and it has been proposed that alterations in these mood states may be precursors of more serious mood disturbances such as depression (Morgan et al., 1987). Nevertheless, it may be erroneous to accept that negative changes in fatigue and vigor, at a level which did not point to overtraining should be regarded as "normal" responses. Adverse changes in vigor and fatigue are detrimental to psychological well-being, the importance of which will be addressed later in this review.

The mood factor tension is defined by adjective items descriptive of heightened musculoskeletal tension, including somatic tension which may be not be observable (tense, on edge) as well as observable psychomotor manifestations (shaky, restless) (McNair et al., 1971). Changes in the mood state tension with increasing training loads have also been documented in swimming (O'Connor et al., 1989; Raglin et al., 1991) and rowing (Raglin et al., 1990), while other sports such as running (e.g. Verde et al., 1992) have not demonstrated such a relationship suggesting that elevation in tension may be sport training specific. However, Morgan et al. (1988) and O'Connor et al. (1991) have not demonstrated any rise in tension in swimmers during training, which confuses the issue still further. Whilst the lengths of periods of swim training may have some effect on perceptions of tension in the latter studies, it remains unclear whether tension follows a dose-response relationship with training.

A more important assertion on the role of tension was made by Raglin et al. (1991) who suggested that perceptions of tension did not necessarily reflect alterations in training volume. In their study, though tension initially became elevated in response to training, during the taper phase tension remained elevated or increased further in swimmers preparing for a conference championship. Raglin et al. (1991) postulated that the tension scale may have reflected a pre-competition anxiety and subsequently that tension may be responsive to both somatic and cognitive-perceptual stressors rather than just the training stimulus itself. O'Connor et al. (1989) also found tension did not return to baseline levels with a competition approaching, and closer inspection of past studies reveals changes in tension have only been found where athletes have been training for a specific competition. Suitably, it may be that elevated levels of tension may represent perceptions about forthcoming competition rather than a symptom of overtraining.

The problems associated with vigor, fatigue and tension have led Raglin (1993) to suggest that the potential of the POMS total mood disturbance score (addition of the five negative mood scores minus the positive mood score) utilised by some researchers (Morgan et al., 1987) could be limited when trying to identify overtrained athletes. However, there is some agreement that elevated levels of the mood state depression may be the primary psychological feature of overtraining (Morgan et al., 1987; Raglin et al., 1991; Raglin, 1993). McNair et al. (1971) indicated that the depression mood factor represented feelings associated with a sense of personal inadequacy, personal worthlessness, futility regarding the struggle to adjust, a sense of emotional isolation from others, sadness and guilt. Morgan et al. (1987) have noted that the symptoms associated with the overtraining syndrome are identical to those found in clinically depressed groups. In developing a scale for monitoring training induced distress in athletes, Raglin and Morgan (1994) also found that five of the seven predictor items identified through discriminant function analysis came from the POMS depression subscale.

Additionally, O'Connor et al. (1989) has shown that levels of depression were significantly higher in swimmers who exhibited large performance decrements. Likewise, Morgan et al. (1988) showed that swimmers who were exhibiting signs of distress during training (measured by physiological and psychological symptoms), experienced a three-fold increase in depression. Whilst elevated levels of depression have also been noted in speed skating training (Guttman et al., 1984) other sports training studies (e.g. Fry et al., 1994; Verde et al., 1992) have not demonstrated any effect. Hence, increases in training volume do not always produce increases in depression but where depression has occurred in tandem with other mood disturbances, sports performers have exhibited other behavioural, physical and performance signs of overtraining. Suitably, it would seem that the presence of elevated perceptions of depression along with other mood disturbances in an athlete mood profile may indicate the possibility of an overtrained state.

The remaining two scales measured by the POMS, anger and confusion, have also demonstrated different responses to training volumes. The anger subscale is proposed to define anger and antipathy toward others, measuring intense, overt feelings as well as milder feelings and suspicious, sullen aspects of hostility (McNair et al., 1971). Levels of anger have increased in a dose-response manner in swimming (e.g. Raglin et al., 1991). However, the sport specific nature of mood state responses to training are again evident, with no changes in anger seen in running (Fry, et al., 1994), rowing (Raglin et al., 1990) and speed skating (Guttman et al., 1984). In addition, the scale of confusion is suggested to be characterised by bewilderment and muddleheadedness (McNair et al., 1971). However, the confusion scale shows the least response to training volumes with only one study (Raglin et al., 1991) documenting a rise in confusion following increased training. Therefore, it may be that perceptions of confusion are not particularly relevant to the sports performer (Butler, 1996) and hence the confusion scale may not be required in monitoring the athlete for signs of overtraining.

In summary, previous studies focusing on the relationship between training loads and mood disturbance have presented contrasting results, with the type of sport training appearing to be a mediating factor. Additionally, the importance of individual differences in mood responses to training has been raised by several researchers (Morgan et al., 1987; 1988; Raglin et al., 1991) with great variability in responses evident in most studies. Raglin and Morgan (1989) have shown that individuals differ in their susceptibility to overtraining, and it seems probable that individual susceptibility and the type of training are determining factors in whether training can lead to maladaptive psychological responses. However, if overtraining has occurred, it appears this is displayed in a mood profile which demonstrates elevated levels of negative mood state, notably fatigue and sometimes tension, but most importantly, depression. Conversely, low levels of vigour are evident, whereas anger and confusion seem to be less affected. The idea of using an "inverse ice-berg" mood profile to identify the overtrained athlete was initially proposed by Morgan et al. (1987) and is currently used in conjunction with physiological measures by the British Olympic Medical Centre in determining whether an athlete is suffering from the overtraining syndrome (Budgett, 1994; Terry, 1995).

Furthermore, other psychological monitoring tools have been constructed in an attempt to focus more closely on the training response (Collins, 1995; Rushall, 1990). For instance, the Daily Analyses of Life Demands (Rushall, 1990) was devised as a means for monitoring training stress and overtraining, and requires athletes to rate symptoms of stress in their lives such as muscle soreness and irritability. Alternatively, mood, sleep and other behavioural markers are monitored via the Psycho-Behavioural Overtraining Scale (Collins, 1995). However, it must be recognised that research has not shown whether these tools accurately and reliably differentiate overtrained from intensely trained athletes (Hooper & MacKinnon, 1995).

It is important to recognise that previous research monitoring mood states has focused almost exclusively on endurance sports training. However, the training demands of other sports not traditionally thought to be at risk of overtraining athletes may promote equally negative psychological moods. Preliminary evidence has been provided by Raglin, Eksten and Garl (1995) who showed that there were negative changes in all mood states (except confusion) in response to a pre-season basketball conditioning programme consisting of mixed endurance (anaerobic and aerobic) training. In contrast, however, Murphy, Fleck, Dudley and Callister (1990) have shown only partial mood changes during a judo training programme. These authors proposed that the psychological make-up of an athlete in a combative sport, such as judo may influence the psychological response pattern to high volume training, specifically that combative athletes would be less likely to experience negative mood states. Such a proposal has some intuitive appeal, and furthermore, Goss (1994) has shown that swimmers who scored highly on the personality characteristic of hardiness experienced fewer mood disturbances over a training period in comparison to swimmers who displayed lower scores on hardiness. Hardy individuals are thought to experience less stress through their appraisal of life events and are considered to be more apt at utilising effective coping strategies to reduce the stressfulness of a situation (Goss, 1994). It is plausible that the hardiness characteristic may be a feature of the psychological make-up of combative athletes referred to by Murphy et al. (1990). The findings of Goss (1994) may also shed further light on previous findings on the importance of individual susceptibility to overtraining (Raglin & Morgan, 1989).

There are many benefits in monitoring mood states during training. One benefit may lie in assisting the coach to determine whether the tapering phase of training before competition has enabled full recovery from high volume training. Past research (Guttman et al., 1984; Koutedakis, Budgett & Faulmann, 1991; Morgan et al., 1987; O'Connor et al., 1989; Raglin et al., 1995; Wittig et al., 1989) has shown that reduced training and rest results in improved mood state; however Murphy et al. (1990) showed that feelings of anger, tension and depression did not return to pre-training levels following a taper phase, suggesting that judo athletes did not "peak" psychologically after increased sport specific training. Whilst it has been recognised earlier in this review that individual mood states such as tension may rise in the taper period, it would seem beneficial to assess if the somatic-related moods of fatigue and vigor (Raglin, 1993) have responded positively to reduced training. No changes following reduced training may indicate problems such as an insufficient taper period.

Another benefit may be the potential for balancing workloads against the psychological well-being of the athlete. For example, if boxing training were to promote the risk of overtraining, it may be possible to use mood state monitoring to identify boxers showing signs of maladaptive responses during training and consequently reduce the workloads in order to maintain the boxers' well-being. The titration of individual workloads as a result of mood monitoring in training has been suggested by Morgan et al. (1987; 1988) and used successfully in Olympic canoeists (Burglund & Safstrom, 1994).

The importance of the individual's psychological well-being during training has been addressed by Spargo and Horsley (1994). These authors have used a cognitive appraisal approach to suggest why athletes may respond with negative moods in training periods. In this approach, athletes are considered to be continually appraising their ability to cope with the demands of intense training. This process involves assessing perceived training demands against perceived personal coping resources. When the perceived demands are considered greater than perceived resources athletes are likely to experience negative moods. Conversely, if athletes perceive they have the ability to cope with the demands, there will be little or no mood disturbance.

Spargo and Horsley (1994) have further suggested that when athletes experience negative mood in training, they may actually tell themselves that they are more fatigued than they really are. Evidently, such perceptions may play a significant role in the quality of training completed. More precisely, if athletes perceive themselves as fatigued it may be that the perceptions of effort required to continually train may lead to decreased effort. In terms of cognitive appraisal, this suggests that athletes may decrease effort in order to lower the perceived demands of training, and hence not outweigh their perceived coping resources. Suitably, it appears that any level of mood disturbance during training (whether indicating overtraining or not) may be detrimental to subsequent effort expended by athletes and may affect the quality of training completed. Hence, it would seem important to identify strategies which minimise mood disturbance during training programmes.

Section 3:
Upper Respiratory Tract Infections and Salivary IgA/Innate Immune Function in Athletes

A relationship between intense exercise and susceptibility to illness was noted early this century. Cowles (1918, cited in MacKinnon, 1992) reported that most cases of pneumonia at a boys' school occurred in athletes, and that respiratory infections seemed to increase after intense exercise and competitive sport. More recently, sports medicine has become increasingly concerned with frequent anecdotal reports that heavy training loads, the overtraining syndrome and competitions are associated with the occurrence of upper respiratory tract infections (URTI). For instance, Weidner (1994) cites a report of more than 800 cases of URTI in the 1980 Winter Olympics. Anecdotal evidence in amateur boxing appears to suggest the same trend, with boxers seemingly more susceptible to colds, sore throats and other infections during periods of intense training (Kelvin Travis, ABA Staff Coach, personal communication, 1994).

Nieman (1994a) has proposed a "J" shaped model which proposes a relationship between exercise and the susceptibility to infection. This model suggests that while the risk of URTI may decrease below that of a sedentary individual with moderate exercise, the risk of infection may rise above average during periods of excessive high intensity exercise. Certainly, such a model would suggest that intensive athlete training programmes may place individuals at extreme risk of contracting infections. The potential problems of URTI for athletes are outlined by Weidner (1994) who suggests that at best infections will result in the loss of important training time or reduce the quality of training. The worst outcome of an URTI was considered to be the missing of competitions, although more complicated viral strains could have more lasting effects (Weidner, 1994).

URTI's consist of a number of acute illnesses such as pharyngitis, croup, epiglottitis and the common cold (Weidner, 1994). Infections are transmitted from person to person by contact with respiratory secretions containing viruses or bacteria. A virus may gain entry to the respiratory tract via small or large particle aerosols, by direct contact or by indirect contact involving environmental objects (Heath, Macera & Nieman, 1992). The young adult has between one and six URTI's per year and common population averages are 1.5-2 episodes per year (Brenner, Shek & Shephard, 1994).

To date, epidemiological research examining the relationship between URTI and physical activity has invariably used self-reported symptom diagnosis of URTI, typically measuring only the incidence of symptoms associated with the common cold (eg. sore throat, runny nose, cough). The link between exercise and the incidence of other upper respiratory infections has not been clearly identified (Weidner, 1994).

Studies revealing increased URTI incidence as a result of physical activity have focused primarily on runners (Brenner et al., 1994). For example, Peters and Bateman (1983) reported that out of 150 runners questioned about URTI after a 56km ultra-marathon race, symptoms were most common in those who achieved the fastest race times and in those who had the highest weekly training mileages. Similarly, Nieman, Johannson, Lee and Arabatzis (1990) showed that distance runners reported higher rates of URTI than in similarly trained runners who did not compete in the Los Angeles marathon. Additionally, Heath, Ford, Craven, Macera and Pate (1991) reported a dose-response relationship between yearly training distance and the incidence of URTI. It appears that the incidence of URTI may be related to variables such as distance, frequency and intensity of training, as well as performance level and participation in competition.

Whilst epidemiological studies have consistently found a relationship between exercise and URTI, the varying methods used in these investigations make it difficult to draw conclusions. Many have used retrospective methods to document symptoms of URTI, with as much as a two month recall in some studies (Nieman et al., 1990). Additionally, the use of different URTI symptom checklists and the infrequent use of randomized control groups has confused findings (Weidner, 1994). Heath et al. (1992) recognised the need for physician confirmed illnesses rather than self-reported symptoms in order that definitions be consistent throughout studies. Equally, Cannon (1993) highlighted the unavoidable drawback that exposure to pathogens is unknown and uncontrolled throughout past research. Accepting all these limitations, the predominant use of runners in past research also raises the question whether it is only runners who are more susceptible to infections, or conversely that the findings can be generalised to the whole athletic population.

The mechanisms responsible for the seemingly high incidence of URTI among athletes are not known (Mackinnon, 1992). Studies have reported changes in blood immune parameters in response to exercise (e.g. Baj, Kantorski, Majewslea, Zeman, Polcoca & Fornalczyk, 1994), however mucosal immunity is the primary defence against URTI (MacKinnon et al., 1993 a). The mucosal surfaces of the naso and oropharynx are the first line of defence against URTI and it has been suggested that respiratory mucosal processes are negatively affected by exercise (McDowell, Chaloa, Housh, Tharp &

Johnson, 1991). Nevertheless, before a review on the studies which have focused on the mucosal response to exercise and how it may be compromised, a brief overview of the immune defence against URTI must be given.

The immune system protects against, recognises and destroys elements which are foreign to the body and can be divided into two areas: primitive innate (natural) and adaptive (acquired) immunity which work together in a cordinated manner (Brenner et al., 1994). Innate immunity is the first aspect of the immune system in the upper respiratory tract encountered by an invading microorganism. In the upper respiratory tract, innate immunity consists of physical barriers (e.g. saliva, nasal and bronchial cilia), chemical barriers (e.g. lysozymes, lactoferrin) and cells (e.g. macrophages, monocytes) to prevent infection. The oral pharynx is protected by the mechanical washing effect of saliva and the cilia lining the upper respiratory tract epithelium which trap and sweep away bacteria. Likewise, the antipathogenic proteins in saliva such as lysozymes and lactoferrin have the ability to kill and degrade microorganisms, whilst macrophages and monocytes ingest and destroy organisms, bacteria and tumour cells in the mucosa of the upper respiratory tract (Smith, 1995).

If the innate system fails to protect, an acute infection may result and the acquired immune system is activated. This results in clearance of the pathogen and the development of memory for the infectious agent. Acquired immunity involves actions of immune cells that inactivate and destroy microorganisms by several mechanisms. The acquired immune response can be divided into humoral and cell mediated responses (Mackinnon, 1992).

In the humoral branch of acquired immunity, immunoglobulins form the highly effective antibody defence against invading viruses and pathogens and are produced and secreted by B plasma cells in mucosal tissues such as the bronchus associated lymphoid tissue, being found in saliva, nasal and other body fluids (Mackinnon, 1992). The secretory or mucosal immune system functions to protect the surfaces of the upper respiratory and gastrointestinal tracts exposed to the environment and is known to be the first acquired immune defence against microorganisms causing URTI (Tomasi & Plaut, 1985).

Salivary Immunoglobulin A (S-IgA) is the principal immunoglobulin in the secretions coating the mucosal surfaces of the nasopharynx, oropharynx, conducting airways, eyes, gut and bladder, and has been found to play a major role in protection against URTI's by inhibiting attachment and replication of pathogenic microorganisms and neutralising toxins and viruses (Tomasi & Plaut, 1985). The concentration of S-IgA in mucosal fluids such as saliva has been found to correlate more closely with resistance to certain viruses than do serum antibodies or other immune parameters (MacKinnon, 1992). Additionally, Mackinnon, Ginn and Seymour (1993a) have shown that a temporal relationship exists between decreased concentrations of S-IgA and the onset of the URTI. Suitably, as levels of S-IgA are thought to be a good indicator of upper respiratory immune function (Fitzgerald, 1988), and athletes appear to be more susceptible to URTI (Heath et al., 1991), S-IgA levels have been studied in a variety of sports and controlled laboratory exercise experiments designed to assess the effects of exercise on immune function.

Research findings have been equivocal, with the type, duration and intensity of exercise variables contributing to conflicting results. Several studies have shown S-IgA concentrations decrease after intense endurance exercise such as cross-country skiing (Tomasi, Trudeau, Czerwinski & Erredge, 1982), distance running (Muns, Liesen, Riedel & Bergman, 1989) and cycling (Mackinnon, Chick, van As & Tomasi, 1989). Similarly, McDowell, Hughes, Hughes, Housh, Housh and Johnson (1992) reported that S-IgA concentrations decreased significantly after a maximal treadmill run to exhaustion.

In contrast, McDowell et al. (1991) reported that S-IgA concentrations did not change following moderate exercise at 50-80% of maximal oxygen consumption. Furthermore, a confusing result was found by Schouten, Verschuur and Kemper (1988) who documented increased S-IgA in men, but decreased concentrations in women following a maximal treadmill test, however this finding has not been replicated in other studies (Mackinnon, 1992).

Research has also shown that S-IgA concentrations may remain suppressed for several hours after intense endurance exercise (Mackinnon et al., 1989), which would have implications for athletes training several times per day over an extended period of time. However, longitudinal studies examining cumulative exercise effects on S-IgA have also produced equivocal findings. Tharp and Barnes (1990) followed swimmers' S-IgA responses across a season, with saliva samples collected in light, moderate, heavy intensity and taper training periods. Significant decreases in S-IgA occured in the heavy training period, and pre to post training decreases in S-IgA were also reported in the heavy training and taper periods. Alternatively, McDowell et al. (1992) reported that although S-IgA concentrations decreased significantly post maximal treadmill test, subsequent run training for 10 weeks did not affect S-IgA levels. In further contrast, Tharp (1991) showed that S-IgA concentrations increased after specific basketball games and practices as well as across a basketball season.

Methodological problems may have also contributed to the inconsistent research findings. For instance, some studies have documented the S-IgA response in parotid gland saliva (e.g. Mackinnon et al., 1989), whilst others have taken whole saliva collections which contain all the saliva collected in the mouth from the parotid, submandibular and sublingual saliva glands (Tharp, 1991). The importance of the site of collection is emphasised by Jemmott and McClelland (1989) who have argued that S-IgA measures in whole saliva are related to the incidence of infection and thus provide a more complete picture of S-IgA immune status than that from a single salivary gland. Hence, whole saliva collection seems preferable to saliva from any one particular gland in the oral cavity when monitoring the relationship between saliva and its constituents and URTI.

Similarly, some research protocols have stimulated saliva production with citric acid and lemon drops (e.g. Schouten et al., 1988), whereas others have not stimulated saliva flow (e.g. Mackinnon et al., 1993a). The impact of artificial stimulation on saliva flow rate has implications for the subsequent S-IgA concentrations found. When saliva flow is stimulated, the large volume produced tends to cause a diluting effect on S-IgA concentration (Brandtzaeg, 1971). Stone, Cox, Valdimarsdottir and Neale (1987) have documented that S-IgA concentrations decrease two to four fold with increased saliva flow following stimulation. This relationship between artificially increased saliva flow rates and decreased S-IgA concentrations has profound implications for the studies that have stimulated saliva collections, where lowered S-IgA concentrations found may be due to the artificial stimulation of saliva rather than a negative effect of exercise. It would appear, therefore, that studies documenting the S-IgA responses may have been affected by one or more methodological problems involving the collection of saliva.

Consequently, researchers in recent studies have used unstimulated whole saliva, measured salivary volume and have timed the saliva collection period. The influence of saliva flow on S-IgA concentrations has come under particular scrutiny in recent sports research (Mackinnon et al., 1993b; Mackinnon & Jenkins, 1993; Mackinnon & Hooper, 1994; McDowell, Weir, Eckerson, Wagner, Housh & Johnson, 1993; Koutedakis, Sabin & Perera, 1995). Mackinnon & Jenkins (1993) have argued that S-IgA/exercise studies need to report saliva flow rate data in order to obtain biologically relevant and more accurate indications of S-IgA output following exercise. Measuring saliva flow rates enables the researcher to control for any decreased salivary flow as a result of decreased parasymphathetic activity during exercise (Wilmore & Costill, 1994) and hence the opportunity to report S-IgA secretion rate per unit of time (IgA concentration multiplied by saliva flow rate). Evans, Bristow, Hucklebridge, Clow and Walters (1993) have also expressed the need to control for saliva flow in S-IgA studies. These authors found an inverse correlation between the volume of saliva produced and the S-IgA concentration in unstimulated saliva collections.

In adopting salivary flow measures, Mackinnon and Jenkins (1993) showed that whilst S-IgA concentrations increased by 10-30% following supramaximal interval exercise, S-IgA secretion rate decreased significantly, primarily as a result of 50-60% decreases in saliva flow. Whilst the authors used these results to highlight the potential erroneous results when focusing solely on S-IgA concentrations, they also proposed that the S-IgA concentrations should have increased in proportion to the decreases in salivary flow if the exercise was not immunosuppressive. As this was not the case, the authors suggested that the supramaximal exercise may also have caused a reduction in S-IgA production and output, in addition to inhibition of saliva flow. Mackinnon and Jenkins (1993) subsequently proposed that the transport of S-IgA across the epithelial cell in the salivary gland is one aspect of the process of secretion of S-IgA which may be negatively affected by exercise.

MacKinnon and Jenkins (1993) have also argued that S-IgA concentrations should be adjusted for total protein concentrations in saliva in order to better reflect changes in the composition of saliva following exercise. Mackinnon and associates have cited negative changes in S-IgA concentrations relative to total protein (Mackinnon et al., 1993a,b; MacKinnon & Jenkins, 1993; Mackinnon & Hooper, 1994) and have suggested that controlling for total protein may account for the changes in saliva volume seen as a result of exercise drying the oral surfaces, and also reflect IgA output relative to other salivary proteins.

Nevertheless, in a comprehensive discussion of S-IgA measurement and analysis, Brandtzaeg (1971) and Tomasi and Grey (1972) have documented evidence to show that in addition to measurement problems, the total protein concentration in saliva varies widely within the same individual at different times, and warned against the expression of S-IgA concentrations in terms of its relation to total protein due to the danger of producing misleading results. Indeed, in a later review, Tomasi and Grey (1987) commented that they were not aware of any reliable techniques for measuring total protein concentrations in saliva, suggesting that accurate determination would require individual assays of each constituent protein. The conclusions from this review were that it is preferable to express the concentrations of S-IgA in terms of its relation to saliva flow (S-IgA secretion rate). This directive has also been supported recently by Miletic, Schiffman, Miletic and Sattely-Miller (1996).

Longitudinal studies which have documented saliva flow rates and hence the S-IgA secretion rate response to exercise have also produced equivocal findings, with the type, duration and intensity of exercise variables again seemingly influencing results. For instance, Mackinnon et al. (1993b) showed that kayakers demonstrated acute 27-38% S-IgA secretion rate decreases following individual interval training sessions, and also showed cumulative changes in S-IgA concentrations over a three week training period. Acute changes in S-IgA secretion rate were also reported by MacKinnon and Hooper (1994) following running sessions, with a non-significant trend towards decreased S-IgA secretion rate also emerging after three consecutive days of training. MacKinnon and

Hooper (1994) cite further potential cumulative effects of training on S-IgA in reporting evidence of reduced levels of S-IgA concentrations in overtrained elite swimmers following a six month season, which suggests that long term training may have negative effects on S-IgA immune function.

In contrast, Koutedakis et al. (1995) showed no acute or cumulative changes in S-IgA concentrations or S-IgA secretion rate following consecutive weeks anaerobic and aerobic swim training. Additionally, McDowell et al. (1993) reported no change in S-IgA secretion rate responses following a 10 week weight training programme, whilst a single weight lifting workout resulted in a 25% increase in S-IgA secretion rate. However, McDowell et al. (1993) did find considerable inter-individual differences in S-IgA responses, with some subjects increasing S-IgA levels, and others decreasing following the same exercise bout. Evidently, the type of exercise may be important, but the intensity and duration of the exercise relative to the individual may be a more prominent factor in determining whether an exercise bout is IgA suppressive, enhancing or has no effect (Heath et al., 1992).

Saliva flow rate and volume has also been shown to reduce considerably during exercise, probably as a result of increased autonomic nervous system sympathetic output which limits the water content in saliva (Pilardeau, Richalet, Bouissou, Vaysse, Larmignat & Boom, 1990; Powers & Howley, 1990; Wilmore & Costill, 1994). Provenza and Siebel (1986, cited in MacKinnon & Jenkins, 1993) have also documented the vasoconstriction of arterioles within the saliva gland with increased sympathetic output which could contribute to a reduction in saliva flow during exercise. The depression of saliva flow during exercise also has implications for the initial innate immune defence against URTI. Saliva is the main fluid in the upper respiratory tract, trapping inhaled pollutants and pathogens through its mechanical washing effect and via its constituent anti-pathogenic proteins, and is central to the immunological defence of the upper respiratory tract (Reynolds & Merril, 1991). The hydration status of the individual can also negatively affect saliva flow rate (Kerr, 1961, cited in Shannon, 1966), hence dehydration through exercise may substantially reduce saliva content on the mucosal surfaces, and thus may leave the individual more susceptible to URTI through impaired innate defences.

Other physical barriers in the innate immune system protecting the individual against URTI may also be affected by exercise. Recent research by Muns, Singer, Wolf and Rubinstein (1995) suggests that nasal mucociliary clearance is impaired up to several days after strenuous exercise. Inhaled pathogens are constantly cleared by active beating cilia on the surfaces of the respiratory mucosal tract (Reynolds & Merril, 1991), and defects in ciliary function have been shown to predispose to respiratory infection (Cole, 1991). The effects on saliva flow and cilia function may provide the evidence to support the claim by Peters and Bateman (1983) that high ventilatory flow rates during prolonged exercise may adversely affect the mucosal surfaces of the upper respiratory tract. Indeed, Peters (1997) and Shephard, Verde, Thomas and Shek (1991) have suggested that following exercise there may be an increased risk of infection in the upper respiratory tract due to the drying of the airways resulting in increased viscosity of mucous, decreased salivary volume and its associated washing effect and decreased ciliary actions.

Chemical barriers in the innate immune system defence against URTI have also been shown to be compromised through exercise. Koutedakis et al. (1995) reported reduced salivary lysozymes following anaerobic and aerobic swim training. Salivary lysozymes function to degrade invading bacteria cell walls. Additionally, Mackinnon (1992) has reported evidence of impaired phagocytic function following exercise, indicating possible adverse effects on the cellular branch of the innate immune response. Furthermore, Mackinnon (1992) has remarked that the innate immune response to exercise has not been thoroughly explored. Hence, aspects of the innate response should not be overlooked when assessing whether exercising individuals are more susceptible to infection.

In summarising the research to date, it would seem that although the experimental designs and protocols are inconsistent, certain types of exercise appear to consistently have detrimental effects on innate and acquired immune system responses protecting the upper respiratory tract. Intense, interval exercise and cumulative heavy training loads have been shown to have negative effects in swimming (Tharp & Barnes, 1990), kayaking (Mackinnon et al., 1993b) and supramaximal cycling (Mackinnon & Jenkins, 1993). These findings suggest that similar types of training schedules and intensities could also be immunosuppressive for boxers.

Section 4:

Massage Effects on Regeneration, Recovery and Performance in Sport

Rest and recovery are crucial aspects of an athlete's training programme which generally serve two main functions. Firstly, rest ensures regeneration of work capacity after training, and secondly, it serves to produce the optimal result from the effort expended in the previous training session (Jarovet, 1987). Moreover, Wylie (1981) suggested that great care should be spent in ensuring that rest serves the purpose of accomplishing optimal training effects.

The importance of rest has also been addressed in reference to its role in avoiding the negative psychological and physiological effects of intense training (Calder, 1990; Fox & Crampton 1987; Fry et al., 1991; Jarovet, 1987; Wylie, 1981). In further describing this process, Calder (1990) also distinguishes between the terms recovery, restoration and regeneration. Recovery is argued to be a generic term to describe the restoration of parameters in either or both physiological and psychological states. Alternatively, restoration refers explicitly to returning physiological markers to normal levels, whereas regeneration refers to the recovery of psychological traits, specifically those associated with mood (Calder, 1990).

The scheduling of modalities designed to achieve optimum recovery has generally incorporated both active and passive methods (Wylie, 1981). For instance, nutrition, psycho-regulatory training, saunas, spas, flotation tanks and warm baths have all been recommended as worthwhile practices to facilitate the recovery process (Spargo & Horsley, 1994). However, another frequently used modality designated to provide both restoration and regeneration following training is that of massage (Samples, 1987).

Massage can be defined as manipulation, methodical pressure, friction, rubbing and kneading of the body (British Medical Association, 1995) and is argued to have both mechanical and reflectory effects (Calder, 1990; Ylinen & Cash, 1988). Mechanical effects are thought to be friction warming, pumping circulation, stretching of soft tissue, breaking scar tissue and fibrous adhesions, increasing microcirculation, enzyme release, increasing tissue elasticity and improving tissue permeability. Reflectory effects are considered to be relaxation, pain reduction and opening microcirculation (Calder, 1990). These effects are principally achieved by such classical methods as effleurage (stroking), petrissage (kneading), tapotement (percussion) and friction (intensive stroking) (Ylinen & Cash, 1988).

Massage has been a therapeutic modality in most cultures since early civilization and has had a long tradition of use in sport. Callaghan (1993) and Goats (1994a) have charted the early history of massage starting in the early civilizations of Babylon, Assyria, China, India, Ancient Greece and Rome. Whilst the use of massage appears to have declined in modern hospital physiotherapy departments (Goats, 1994b), it has maintained a high profile in sport and is often an integral part of an athlete's conditioning (Stamford, 1985). Recent use of massage in sport includes Olympic recognition and acceptance. The number of general leg or body massages carried out by masseurs or physiotherapists on the G.B. team at the Winter Olympics in 1992 was at least 164, whilst at the Barcelona Summer Olympics the number was at least 787 (Callaghan, 1993).

Frequent claims made in the sports literature regarding the benefits of massage include improved stretching of tendons and connective tissue (Samples, 1987), relief of muscle tension and spasm (Ryan, 1980; Stamford, 1985) and elimination of waste products following training (Birukov, 1987; Goats & Keir, 1991; Paikov, 1985). Manual massage is also commonly assumed to enhance muscle recovery from intense exercise, principally due to its ability to speed muscle blood flow (Ylinen & Cash, 1988). Studies to date on blood flow are contradictory. Cafarelli and Flint (1993) point out that reports on limb blood flow vary from no effect of massage to as much as a 50% increase. For instance, positive effects were reported by Dubrovsky (1983, 1990) who showed that massage promotes acceleration of muscle and venous blood flow, increases blood volume, and reduces muscle tightness. In contrast, recent research by Shoemaker, Tiidus and Mader

(1997) and Tiidus and Shoemaker (1995) used a sophisticated Doppler ultrasound method and showed no effect of massage on blood flow irrespective of the type of massage stroke or the muscle mass being treated.

There is the widely held belief that accumulated lactate is at least partially responsible for retarding recovery from fatigue (Gupta, Goswani, Sadhuktan & Mathur, 1996; MacClaren, Gibson, Parry-Billings & Edwards, 1989; Maughan, Gleeson & Greenhaff, 1997). Since it has been proposed that massage could increase blood flow to the muscles being massaged, and blood flow is suggested to be an important factor in the removal of lactate following exercise through enhanced oxidation and diffusion out of the muscles (Bonen & Belcastro, 1975; Dodd, Powers, Callender & Brooks, 1984; Gaesser & Brooks, 1984; Hermansen, 1981), studies have sought to determine whether massage has any effect on lactate removal following an exercise bout.

Research findings have only partially supported any positive effect of massage on lactate removal. For instance, although post exercise blood lactate levels were shown to be significantly lower following a massage compared with a passive rest condition, a warm-down intervention was seen to promote the most efficient lactate removal (Bale and James, 1991). Additionally, Dolgener and Morien (1993) demonstrated superior lactate disappearance in 40% V02 max. cycling recovery compared with massage and passive recovery conditions following short-term exhaustive exercise. More recently, Gupta et al. (1996) published similar results with superior lactate removal following active recovery. No difference in lactate removal between massage and passive recovery following exercise has also been documented using a mechanical massaging device (Zelikovski, Kaye, Fink, Spitzer & Shapiro, 1993). It is widely acknowledged that lactic acid removal is enhanced during active recovery (Wilmore & Costill, 1994) and these findings further suggest that active warm-down strategies may be more efficient than massage at removing lactate during the recovery phase.

In addition to lactate measurement, scientific sport studies have also focused on an array of physiological parameters in seeking to identify the benefits of massage in the recovery from exercise. Positive effects are cited by Balke, Anthony and Wyatt (1989) who showed that mechanical and manual massage aid recuperation from exercise fatigue more effectively than rest alone. Smith, Keating, Holbert, Spratt, McCammon, Smith and Israel (1994) also report sports massage was effective in reducing delayed onset of muscle soreness after exercise, whilst the aforementioned study by Bale and James (1991) also reports a positive effect of massage on muscle soreness after exercise compared to rest and warm down conditions. Finally, underwater jet massage has been used to improve recovery in an array of biochemical parameters in track and field athletes (Viitasalo, Niemala, Kaappola, Korjus, Levola, Monomen, Rusko & Takala, 1995).

In contrast, Isabell, Durrant, Myrer and Anderson (1992) showed that ice massage and ice massage with exercise did not reduce the symptoms of delayed onset of muscle soreness in basketball players. Tiidus and Shoemaker (1995) also report that daily massage of the quadriceps muscle group did not reduce subsequent muscle soreness in subjects who had previously completed an intense bout of eccentric quadriceps exercise. Aarko, Pakarinen and Kari-Koskinen (1983) also failed to find changes in blood parameters in sportsmen following a one hour full body massage. Moreover, in a review on the role of massage in the preparation and recovery from exercise, Cafarelli and Flint (1993) concluded that the literature on physiological parameters did not fully support the widely held notion that recovery from exercise is enhanced by various forms of massage.

It is evident from past research that replications of massage studies are virtually impossible with the type of massage, timing and duration, parts of the body massaged and pressure applied all seemingly down to the individual researchers' preference (Callaghan, 1993). Suitably, while experimental protocols have varied considerably between studies, there is some doubt whether massage may be an effective modality to relieve physical fatigue and hence enable more efficient physiological restoration for athletes between training sessions. Nevertheless, previous authors have recognised that psychological regeneration after intense training must be addressed in conjunction with physiological restoration (Calder, 1990; Jarovet, 1987). Whilst the psychological benefits of sports massage are frequently reported (e.g. Samples, 1987; Ylinen & Cash, 1988), these claims are also largely based upon anecdotal evidence, with little scientific evidence supporting the supposed psychological benefits.

A potential pathway for massage enhancing positive affect has been identified by Kaada and Torsteinbo (1989). These authors found a 16% increase in plasma endorphin concentration after massage and suggested that the release of endorphins may be the mediator in the sensation of well-being following massage. Additionally, Longworth (1982) proposed that massage could promote a feeling of well-being through decreased arousal levels. Past research into the effect of massage on psychological parameters in the sport setting has been limited by methodological and statistical limitations (Tyurin, 1986). Indeed, Cafarelli and Flint (1993) argue that considerable weight has inappropriately been given to anecdotal accounts and practical experiences in the field which confirm the positive effect of massage on psychological well-being. Nevertheless, of the few empirical studies which have focused on the psychological response to massage, Weinberg, Allen and Kolodny (1988) have provided support for its use.

These authors investigated the relationship between exercise, massage and positive mood enhancement in physical education students. Subjects were randomly assigned to either thirty-minute swimming, tennis, jogging or racquetball classes, a rest/reading control, and a Swedish massage condition. The psychological measures completed were the POMS, the State Anxiety Inventory (Spielberger, Gorsuch & Lushene, 1970) and the general and high activation subscales from Thayer's Adjective Checklist (Thayer, 1967).

Weinberg et al. (1988) found a positive relationship between massage and the POMS, and between massage and Thayer's Adjective Checklist. More specifically, massage resulted in lower levels of tension, fatigue, depression, anger and confusion. Vigor, the positive mood state measured by the POMS did not show any change following massage, however, the authors did indicate the pre-massage scores for vigor were high, and therefore allowed little room for improvement post massage. Of the other experimental conditions, running was the only other exercise which demonstrated significant positive effects on the dependent variables, but massage resulted in more consistent, higher positive mood enhancement.

If the results of Weinberg et al. (1988) were generalised to the athlete in heavy training, it is clear that massage could help counteract any negative psychological effects, and hence play a crucial role in psychological regeneration for the athlete. Furthermore, it may be that massage in the training phase could also have a positive effect on perceptions of the POMS subscale vigor (not demonstrated by Weinberg et al., 1988) which has been shown to be highly influenced by training loads (Morgan et al., 1987; Raglin, 1993).

Unfortunately, the role of massage in aiding psychological regeneration from heavy training has not been addressed. Indeed, no empirical data could be found which supports the contention that massage can alleviate maladaptive psychological mood responses to heavy training. Nevertheless, in a study focusing on the regeneration strategies followed by elite Australian athletes, Fox (1986) showed that the use of spa/hydrotherapy, massage and sauna modalities resulted in less negative mood disturbance during heavy training and pre-competition periods.

In this study, athletes were split into the two categories of intentional users and non-intentional users. Intentional users were those athletes who used the regeneration modalities on offer for the specific purpose of gaining a regeneration effect. Non-intentional users were those who reported use of the available facilities purely for recreational purposes. The results gained showed that intentional users visited the facilities more frequently, and though non-significant, intentional users were seen to be less angry, fatigued, confused and more vigourous as measured by use of the POMS. Fox (1986) used these results to call for more education about the benefits of regeneration facilities and techniques, arguing that there was a general lack of sophistication and knowledge about such procedures.

Accounts of the use of massage within boxing in the scientific sports literature are virtually non-existent. However, Zhuravleva and Babkin (1989) found massage of biologically active points increased microcirculation in a group of 25 boxers. Additionally, Mateeva and Tsirgiladze (1985) documented the use of underwater stream massage and hydroelectric baths on various physiological indices. In contrast, anecdotal evidence concerning use of massage within the sport is well documented with massage extensively used for pre-competition preparation, between round and contest recovery and for relaxation purposes. All of these uses have been witnessed by this author as a sport science support staff member to the England and Great Britain Amateur Boxing teams. In contrast, massage is presently rarely used by English boxers for promoting recovery during training programmes.

There are also frequent anecdotal claims in the sports literature that massage can enhance performance (Samples, 1987). In contrast, Cafarelli and Flint (1993) state that scientific literature is not replete with reports of controlled studies designed to answer this question. However, three studies which have shown positive effects of massage demonstrated small increases in muscle endurance and power output (Ask, Oxelbeck, Lundeberg & Tesch, 1987; Balke et al., 1989; Rinder & Sutherland, 1995).

Studies showing no effect of massage on performance parameters include effects on maximal muscle voluntary contraction (Cafarelli, Sim, Carolan & Liebsman, 1990; Witkorsson-Moller, Oberg, Ekstrand & Gillquist, 1983) and stride frequency during sprinting (Harmer, 1991). Furthermore, Boone, Cooper and Thompson (1991) showed no effect of a pre-performance massage on sub-maximal running performance and various physiological markers when compared with a non-massage condition.

During many athletic events the ability to recover quickly from the effects of exercise and fatigue is important and massage is often recommended as a way to improve recovery time and hence play a key role where repeated performance is required (Balke et al., 1989). However, whilst Callaghan (1993) has acknowledged the widespread use of massage to supposedly increase the rate of recovery and enhance the potential of athletes to perform to capacity in the next event, scientific support for the role of massage in exercise recovery and subsequent performance is virtually non-existent.

One study which addressed the role of massage where repeated performance was required found no effect of massage on physiological markers or on overall performance. Drews, Kreider, Drinkard and Jackson (1990) investigated the scientific effects of massage on repeated performance in elite cyclists. Participation in a four day stage race (161 km. day^{-1}) completed with daily post stage massage showed no differences in subsequent daily stage performance times or muscle enzyme levels in pre/post stage and post-treatment conditions when compared with a no massage condition completed 18 days later. Suitably, these findings question whether massage can demonstrate a positive effect on repeated sporting performance.

Nevertheless, it must be recognised that the period between performance conditions (daily stages) in the Drews et al. (1990) study would have included a substantial period of rest as well as the massage treatment. This factor may have been important in the finding of no effect of massage as the cyclists may have had sufficient time to recover without the need for massage intervention. In contrast, other repeated sport performance conditions exist where stricter time demands apply and where massage could have an effect. Boxing is one such example, where in domestic competition victorious competitors may have to box new opponents within a brief period (one hour) of their last bout.

Indeed, in a study where stricter time demands were applied, Zelikovski et al. (1993) found 45% improvements in subsequent exercise performances following a twenty minute massage recovery period when compared with a passive recovery condition. In this study, eleven men exercised at a constant workload until exhaustion. During the recovery, the subjects' legs were massaged using a pneumatic device, immediately after which a second constant load exercise bout was completed. The further finding that cardiorespiratory and blood parameters showed no differences between conditions prompted the authors to suggest a psychological pathway through which massage could positively influence recovery and subsequent performance.

Zelikovski et al. (1993) rightly concluded that improvements in performances following massage were possibly linked with psychological affect, proposing that the subjects perhaps felt better prepared for the subsequent exercise bout. It is evident that the role of massage in psychological preparation for initial or repeated performance has been overlooked in previous research. Whilst this section of the review has been largely concerned with perceptions of mood state and recovery during training phases, the same issues raised would seem to be important when trying to increase the speed of psychological regeneration between performances.

In summary, whilst much anecdotal evidence exists which conveys positive testaments to massage, there is a clear need to apply scientific research principles to further investigate the effects of massage on both recovery from exercise and performance, from a psychological and physiological perspective.

Section 5:

Interdisciplinary Issues involving Mood State, Immune Function and Massage

The need for interdisciplinary studies has been emphasised in a comprehensive commissioned review indicating future directions for performance related research in the sport sciences (Burwitz et al., 1992). These authors highlighted the fact that the majority of previous sports science research has been monodisciplinary in nature, being based in one the three major subdisciplines of sports psychology, exercise physiology and sports biomechanics. Within this review, the potential for interdisciplinary research into the training stress or overtraining field was frequently cited, noting that the relevance of an interdisciplinary perspective to this subject was recognised by associated research reviews in the subdisciplines of sport psychology (Hardy & Jones, 1992) and exercise physiology (Jakeman, Winter & Doust, 1992).

It should first be noted that a distinction has been made between multidisciplinary and interdisciplinary research. Burwitz et al. (1992) have remarked that although the multi/interdisciplinary terms are often used synonymously, a clear distinction can be made between the two approaches. Whilst both approaches emphasise more than one discipline of sport and exercise science working to solve a problem, they can be differentiated in that multidisciplinarity involves disciplines working in an "uncoordinated and unitary manner", whereas interdisciplinarity involves disciplines working together in an "integrated and co-ordinated manner" (p.2-3, British Association of Sport and Exercise Sciences, 1997). In this research programme, it was deemed that the latter perspective would need to be adopted in order to grasp the processes underlying the problems faced by boxers in training. This was in anticipation that awareness of interdisciplinary issues would enhance potential solutions arising from the research.

McCann (1995), Morgan (1989), O'Connor et al. (1991) and Weinberg (1990) have all stressed the opportunities afforded by interdisciplinary research when referring to the problems of researching training stress from a monodisciplinary perspective. These authors suggested that the most effective research strategy would be to assess theoretically relevant physiological, immunological and psychological variables in unison rather than in isolation. Taking these considerations into account it seems surprising that there is not an abundance of literature which has monitored the effects of training loads in an interdisciplinary fashion.

However, when one considers the popularity of monitoring mood states in training studies (Terry, 1995) it is not remarkable that some studies have sought to assess various physiological, biochemical and immunological parameters in tandem with mood. For instance, O'Connor and associates (O'Connor et al., 1989; 1991) have focused on mood state, salivary cortisol and selected performance measures in college swimmers. Swimming has been a popular vehicle for interdisciplinary research with Costill et al. (1988) and Morgan et al. (1988) also publishing separate papers on the relationship between mood, muscle glycogen and performance. Additionally, Raglin et al. (1990) targeted interactions among mood, neuromuscular function and anaerobic power measurements. More recently, the effects of training load on swimmers' mood, sleep patterns and body composition has been documented (Taylor et al., 1997).

The training status of participants in other sports has also been measured through interdisciplinary means in judo (Murphy et al., 1990), rowing (Cogan et al., 1991) and cycling (Pyke et al., 1988). Liederbach et al. (1992) followed professional ballet dancers over five weeks of an intensive ballet season and found mood state monitoring and the measurement of urinary catecholamines to be useful tools in assessing training status.

There have been three studies which have documented immunological and mood state responses in intensively trained athletes. Verde et al. (1992) and Grove et al. (1994) designed laboratory controlled studies to monitor training effects on runners, documenting mood disturbances and cellular immune system suppression (T-lymphocytes and interleukin-2). In both these studies no attempt was made to examine the relationship between psychological and immunological measures.

Furthermore, while previous studies have documented the S-IgA response during heavy training (MacKinnon, 1995), only one study has reported the relationship between psychological variables and S-IgA levels. Tharp and Barnes (1990), mentioned earlier in this review, monitored mood states in swimmers but found no significant correlation between S-IgA and POMS total mood disturbance in any training period. In contrast, MacKinnon and Hooper (1994) have indicated that they have collected unpublished data with elite swimmers which shows significant correlations between S-IgA measures and indicators of mood disturbance measured by the POMS. At the time of writing, this data appears to have remained unpublished. Hence, the relationships between S-IgA and each of the POMS subscales during training does not appear to be established. It is also possible that changes in S-IgA with varying training loads may relate more closely to more distinct mood fluctuations than that of the total mood disturbance score used by Tharp and Barnes (1990).

While the effects of psychological stress on immune function has developed through the field of psychoneuroimmunology (Jemmott & Magloire, 1988; Tecoma & Huey, 1985), health psychology research has not unequivocally demonstrated the link between mood and S-IgA (Evans et al., 1993; Kugler, 1991). Positive mood states induced by watching a humorous film (Dillon, 1985) and relaxation (Green & Green, 1987) have been associated with increases in S-IgA, whereas negative mood states have also been related to increased S-IgA levels (Evans et al., 1993; Stone et al., 1987).

In summary, the relationship between S-IgA and psychological measures is still not fully understood. Moreover, the relationship is under researched in the sport environment, and recent research by Coleman (1995) has shown that S-IgA levels decreased following stressful competitive situations in youth gymnasts, measured via a repertory grid technique. This finding would suggest that the relationship between psychological measures and S-IgA demands further research in the sports setting.

The use of strategies designed to improve recovery post training and performance in athletes would also seem to be a promising avenue for interdisciplinary research. The use of massage is commonplace by athletes and is widely assumed to have both psychological and physiological effects (Cafarelli & Flint, 1993). However, no studies cited earlier in this review have attempted to simultaneously document both aspects when attempting to clarify the possible benefits of massage. The potential for massage to influence psychological, physiological and performance aspects has been highlighted, and if it is considered that recovery from exercise constitutes an interplay between psychological and physiological factors (Calder, 1990; Fry et al., 1991; Wylie, 1981) then it would seem a concurrent analysis is necessary to evaluate any relationship.

Chapter 3

Experiment 1:

Mood State Monitoring During Amateur Boxing Training

Introduction

It has been established that it is common practice for athletes to undergo phases of intensified training in order to prepare for competition. It has also been widely acknowledged that this type of training can have negative psychological and physiological consequences for the athlete. Whilst the search for successful physiological markers of overtraining continues unabated (Kuipers, 1996), many authors have questioned the practicality of these measures because they require invasive procedures and extensive technical support (Hooper & MacKinnon, 1995; Kuipers, 1996). As a practical alternative with seemingly promising results, the monitoring of mood states during training phases has been suggested in numerous reviews in this field (e.g. Eichner, 1995; Fry et al., 1991).

It is evident that the majority of past research utilising the POMS to monitor training status has focused on endurance athletes (Morgan et al., 1987; Terry, 1995). Nevertheless, Raglin et al. (1995) have argued that the presumption that overtraining is assumed to be limited to endurance athletes could be an erroneous one. The lack of research into sports where a significant degree of anaerobic fitness and mixed endurance training was necessary was highlighted as problematic, in that practical help for the athletes involved could be overlooked (Raglin et al., 1995). Amateur boxing falls into this category (Smith, 1993).

Furthermore, the proposition by Murphy et al. (1990) that the psychological make-up of combative athletes may influence the perception of mood during training has obvious implications for amateur boxers who, like judo athletes, take part in a high energy combative sport requiring skilful technique and anaerobic endurance. Generalising the results of Murphy et al. (1990) to boxing would suggest that mood disturbance, and hence overtraining may not be a problem in amateur boxing training. However, anecdotal evidence (I. Irwin, National Coach, personal communication, 1993) suggests that mood disturbances are a common feature seen in boxers when training.

It should also be noted that research following mood state responses during training have used different protocols. Some researchers (Fry et al., 1994; Morgan et al., 1988; Murphy et al., 1990; Verde et al., 1992) have monitored the effects of systematic changes in the training loads of athletes under controlled conditions, whereas other researchers (Cogan et al., 1991; Morgan et al., 1987; Raglin et al., 1991) have followed a naturalistic programme, whereby athletes have been studied during the course of a regular training programme. Anecdotal evidence suggests mood disturbances have occurred in regular amateur boxing training programmes and thus the focus of this study was to monitor and describe the mood patterns associated with training loads in amateur boxers during the course of a normal training programme. From the outset, it was recognised that such a research design did not ensure that any of the subjects would become overtrained, thus the intent was not to induce overtraining or determine when it occurred.

The additional demands that a weight-class sport imposes on athletes may accentuate the risk of specific negative mood states occurring in boxing training. Kreider, Hill, Horton, Downes, Smith and Anders (1995) have shown that reduced carbohydrate intake significantly raised post-exercise levels of self-reported fatigue (measured by POMS) in athletes undertaking a seven day training programme. Previous studies have suggested that depleted muscle glycogen may leave the athlete more susceptible to overtraining (Morgan et al., 1988; Budgett, 1994) and it may be that a restricted diet could lead to heightened feelings of fatigue if boxers attempted to lower calorific input during training in order to lose or maintain weight.

In summary, it is evident that a paucity of research exists on athletes who combine both anaerobic and aerobic training, and on combative, weight-classified sports in particular. Hence, this study sought to clarify the mood state response to amateur boxing training. With knowledge of the demanding regimes undertaken by boxers, and anecdotal evidence suggesting mood disturbances in training, it was hypothesised that there would be changes in the mood states of fatigue and vigor as training intensity increased. Existing literature on endurance sports also indicated that changes may have been found in depression, with anger and confusion less affected. The sample of boxers used in this study were preparing for competition, hence it was also hypothesised that tension related affect would also increase as the training load increased.

Method

Participants

The participants in this investigation were eight members of the Royal Navy Boxing Squad based at H.M.S. Nelson in Portsmouth, Hampshire. The mean age (±SD) was 22.2 (±1.0) years. Prior to the outset of the study, the general requirements were outlined to the coach and squad members. Participants were informed that they were free to withdraw from the study at any point and confidentiality was assured.

Instrumentation

The questionnaire used in this study was a slightly modified version of the original 65 item Profile of Mood States (McNair et al., 1971). The POMS consists of six subscales which assess levels of tension, vigor, fatigue, depression, confusion and anger. To obtain a score for each mood factor, the sum of the responses are calculated for each adjective defining the factor. All items in each factor are keyed in the same direction except for two items, *relaxed* in the tension subscale and *efficient* in the confusion subscale. These items receive negative weights in calculating the factor scores. The number of items comprising each mood factor ranges from 7 to 15. Responses range from 0 (not at all) to 4 (extremely) and the standard instructional set "last week including today" was used in this instance.

Following the suggestions of Gauvin and Russell (1993) on adapting existing psychometric inventories for different cultural populations, four POMS items were changed in an attempt to make the inventory more culturally specific and to avoid ambiguity and interpretation problems. Similar assertions on cultural differences specific to the POMS have been voiced by Albrecht and Ewing (1988) who developed alternative wordlists. The proposed item modifications were scrutinized by a panel of three Accredited British Association of Sport and Exercise Sciences (BASES) Sport Psychologists. The final agreed modifications to the items on various subscales are seen below.

Subscale	Item	New Item
Fatigue	Bushed	Need a Rest
Depression	Blue	Down
Anger	Ready to Fight	Short-Tempered
Vigor	Full of Pep	Powerful

Procedure

Boxers were asked to complete a modified POMS in four training phases during preparation for a major annual championship. The training phases were light intensity, medium intensity, high intensity and taper. The boxers completed the POMS on one occasion during each intensity, in the morning before the first training session. Data collections took place during the middle of each training phase and were separated by two week intervals, and the final collection took place five days before competition.

Training

The progressive training intensities formed part of the boxers' normal training programmes and were subjectively defined by the Royal Navy coach. The content of the training intensities were also independently scrutinised and accepted by the Amateur Boxing Association exercise physiologist (BASES Accredited). The training intensities consisted of various exercises and drills to develop both power and endurance. The squad trained five days per week, with varying frequency of training sessions per day, depending on the training intensity. The first session generally began at 8 a.m., with the final session ending no later than 8 p.m. Typical exercises during each of the training phases are presented in table 3.1.

Table 3.1.Types of Exercise at Each Training Intensity

Light Intensity	**Medium Intensity**
(2-3 sessions per day)	(3-4 sessions per day)
4 mile steady run	5 mile steady run
Gym Session (6*3min.)	Interval run (6*200m)
Technique session	Technique session
Flexibility session	Flexibility session
Fixed load circuit	Muscular endurance arm session
(10 exercises*10 reps*1 lap)	Target circuit (8 stations*30 sec.*1 lap)
	Gym session (6x3min.)
	Fixed load circuit (2 laps)
High Intensity	**Taper**
(4-6 sessions per day)	(2-3 sessions per day)
5 mile steady run	4 mile steady run
Open Sparring	Target circuit (1 lap)
Interval runs (4*400,3*200,2*100m)	Fixed load circuit (1 lap)
Gym Session(8*3min.)	Gym Session(3*3min.)
Fixed load circuit (3-4 laps)	Speed Runs
Target circuit (2-3 laps)	Flexibility session
Interval Gym work (15*90sec.)	
Fartlek run	
Flexibility session	

Note: The daily programmes for the boxers would incorporate some of the sessions noted above, as well as boxing specific drills and exercises.

Results

Means and standard deviations for the mood variables at each training intensity are presented in table 3.2.

Table 3.2: POMS Subscale Means (±SD) Across Training Intensities

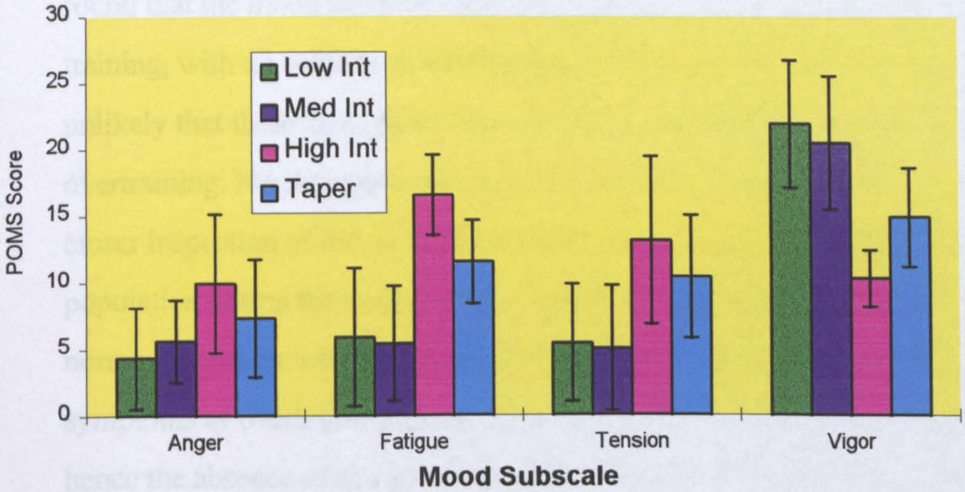
	Low Int	Med. Int	High Int	Taper
Anger	4.3 (3.8)	5.6 (3.1)	9.9 (5.2)	7.3 (4.4)
Confusion	5.0 (4.3)	5.5 (3.8)	7.0 (3.5)	6.6 (4.6)
Depression	4.5 (5.2)	4.4 (4.9)	6.3 (6.0)	5.8 (5.3)
Fatigue	5.9 (5.2)	5.4 (4.3)	16.5 (3.0)	11.5 (3.1)
Tension	5.4 (4.4)	5.0 (4.7)	13.1 (6.3)	10.4 (4.6)
Vigor	21.9 (4.8)	20.5 (5.0)	10.3 (2.1)	14.9 (3.7)

The standard deviations seen within table 3.2 indicate some degree of variance within each mood factor, hence the presence of individual differences between boxers. The mood states vigor and fatigue appeared to show the largest factor totals across the four training phases.

A series of one-way Repeated Measures ANOVA, with time as the repeated measure, revealed differences in tension ($F_{3,21} = 30.23$, $p<0.001$), anger ($F_{3,21} = 12.79$, $p<0.001$), vigor ($F_{3,21} = 49.03$, $p<0.001$) and fatigue ($F_{3,21} = 51.57$, $p<0.001$). No changes over time were found in depression ($F_{3,21} = 0.73$, $p>0.05$) and confusion ($F_{3,21} = 1.00$, $p>0.05$) subscales. Post hoc Tukey tests showed no significant differences between the light intensity and medium intensity training phases in any POMS subscale. Tension, anger, vigor and fatigue showed significant negative shifts in the high intensity training phase, with tension, vigor and fatigue exhibiting significant positive shifts towards the light/medium intensity levels in the taper period. Anger returned to the light/medium intensity levels in the taper phase. These changes can be seen in figure 3.1.

Figure 3.1.

Mood State Changes Across Training Intensities



Discussion

The primary finding of this study was that amateur boxers are prone to mood disturbances during training. The dose-response findings of this study replicate previous research on endurance athletes (e.g. Morgan et al., 1987; Raglin et al., 1991), and also provides further evidence of mood disturbances in sports requiring mixed endurance training (Raglin et al., 1995). In contrast, the mood disturbances found in amateur boxers indicate no support for the contention of Murphy et al. (1990) who proposed that athletes in combative sports would show little mood disturbance during training.

Murphy et al. (1990) based this proposal on their findings with elite judo players, and it could be argued that the monitoring of sub-elite amateur boxers in this study may have influenced the results. However, Raglin (1993) has noted that mood disturbances have been found across all levels of competition and this would suggest that elite amateur boxers may be just as susceptible to mood disturbances during training as the sub-elite boxers monitored in this study.

Congruent with other studies focusing on the relationship between training loads and mood disturbance, amateur boxers also displayed inter-individual differences in mood responses to a normal overload training programme. Likewise, analysis of group scores on specific mood states showed some similar trends to past research. For instance, this study found that the mood states of vigor and fatigue are the most sensitive to amateur boxing training, with all subjects exhibiting large changes on these mood states. However, it is unlikely that these changes in vigor and fatigue necessarily point to the presence of overtraining. No changes in the subscale depression were seen across training phases, and closer inspection of individual depression scores revealed all subjects fell within population norms for male college students (McNair et al., 1992) and recently published norms for athletic samples (Terry & Hall, 1995). Morgan et al. (1987) have noted that the symptoms of overtraining are identical to those found in clinically depressed groups, hence the absence of any psychopathology suggests the boxers were probably not overtraining.

Nevertheless, the assertion by Terry (1995) that intra-individual changes in mood profiles may be of more importance than comparison to published norms may suggest that small individual shifts in feelings of depression could indicate that athletes are showing early signs of overtraining. Two boxers exhibited some small changes on the depression subscale during heavy training and it could be argued that these individuals were showing signs of distress. Previous psychological research has not indicated exactly when overtraining occurs (Collins, 1995) and it would seem that an inherent problem with mood profiling remains, in that it is difficult to ascertain precisely when training stress becomes overtraining.

Changes in the mood state tension also seemed to mirror previous research findings, where disturbances have only been demonstrated where athletes have been training for a specific competition (O'Connor et al., 1989; Raglin et al., 1990, 1991). The competition element had driven Raglin et al. (1991) to suggest that changes in tension do not necessarily just reflect changes in training volume, and have argued that tension may be responsive to both cognitive and somatic stressors. The monitoring of amateur boxers supports these contentions with the increases in tension seen in the heavy training phase accompanied by only moderate reductions in the taper phase when physical training was substantially reduced. Suitably, whilst the elevated levels in the heavy training phase may be an effect of somatic and cognitive stressors, the elevated levels of tension in the taper phase may represent cognitive concerns about the approaching boxing competition. Nevertheless, the findings of this study do not enable a clear understanding of the weighting of cognitive and somatic stressors on tension related affect. The final data collection took place halfway through the taper period and it would have been interesting to monitor the tension mood state closer to the day of competition to discover if it reduced further, remained at the same level or elevated still further.

The remaining two scales measured by the POMS raised some interesting issues for the monitoring of amateur boxing training. Firstly, there were raised levels of anger seen during heavy training which during the taper period returned to the lower levels seen in light and medium intensity training periods. Only two studies have seen changes in this mood state (Murphy et al., 1990; Raglin et al., 1991) hence the training load/anger relationship seems difficult to explain. However, anger related affect in this study may be linked to the boxers' interpersonal relationships and amount of time they must spend in each other's company. The fact that anger affect fell rapidly from the high intensity training to taper collection may reflect the degree of close interpersonal contact during heavy boxing training where the number and duration of training sessions is higher and longer compared with the reductions in training volume seen during the taper period. More precisely, items on the anger subscale such as *irritable* and *bad-tempered* may point to feelings associated with interaction with others. It is possible that this close and intense interaction during training, particularly in a combative sport, may have a negative effect.

Finally, the mood state confusion showed no change across all training phases. This is in accord with previous research, where only one study has documented a significant change on this subscale with increases in training load (Raglin et al., 1991). The original POMS was developed for use in mental health research where feelings of confusion may indicate abnormal psychological states (McNair et al., 1971). However, Butler (1996) has suggested that monitoring for feelings of confusion may not be relevant for the sports performer and the low mean scores recorded would suggest that confusion related affect was not regularly experienced by the amateur boxers in this study. Therefore, the finding of no effect on this subscale, coupled with similar findings in past research suggests that the confusion subscale could be omitted for future monitoring of mood states in amateur boxing training.

While mood disturbances were seen in the high intensity training phase, it is interesting that no disturbances were noted from low to medium intensity training phases. This would suggest that training intensity and volume must reach a critical point before mood changes become apparent, and this may shed further light on inconsistent results on the precise mood/training load relationship in previous research. It is clear that exact levels of training load are hard to replicate across different sports, as are the variety of experimental conditions used. Moreover, Morgan et al. (1987) and Goss (1994) have suggested that a twofold increase in training volume and intensity is required for overload training, and it may be that such an increase was not present between the light and medium intensity training phases in this study. This factor may also explain why previous studies have yielded differing results on the mood response to training.

On a more practical level, the monitoring of mood states in this study suggests that some boxers may not have fully recovered from high intensity training and hence may not have peaked psychologically after increased sport specific training. Although levels of tension remained high and may be linked to cognitive concerns about competition, the finding that fatigue and vigor related moods remained affected could suggest that boxers were still feeling the effects of the training programme well into the taper phase. However, the demands of a weight-class sport often require boxers to dramatically reduce calorific and fluid intake in the taper phase before competition and these factors may also promote negative mood states. Keith, O'Keeffe, Alt, Blessing and Wilson (1987) and Kreider et al. (1995) have reported that reduced carbohydrate intake and dietary deficiencies in athletes are related to increase self-reported levels of fatigue. Likewise, Smith, Baldwin, McMorris, Fallowfield and Hale (1996) have shown that dehydration similar to that experienced by amateur boxers during weight-making lead to decreased perceptions of vigor and increased fatigue measured via the POMS. Therefore, it seems likely that the levels of fatigue and vigor seen in the taper phase may be due to a combination of any lingering effects of the training programme and any weight-making process employed by the boxers.

The present study also included some changes to the original 65 item POMS in an attempt to make the inventory more culturally specific and to try to avoid interpretation problems with some items. Terry (1995) has voiced concerns over comprehension of some POMS items and has suggested that subjects should be supplied with culturally appropriate alternative wordlists to minimise misunderstandings. Czechoslovakian and Swedish sport researchers have previously faced this cultural problem and have produced adapted versions of the 65 item POMS, including slight modifications from the original U.S. version to correspond with the sociocultural aspects of their countries (Burglund & Safstrom, 1994; Man & Krejci, 1985). Grove and Prapavessis (1992) also recognised cultural difficulties with several POMS items and included changes in their shortened version to reflect Australian cultural aspects. Items changed in this study such as *full of pep, bushed and blue* seem to be better established in the North American culture (Terry, 1995). Moreover, the item *ready to fight* on the anger subscale could clearly be interpreted as ready to compete by boxers, rather than tapping into anger related emotion.

Suitably, the items used as replacements in this study are justified according to the recommendations of previous authors discussing cross-cultural psychometric research tools (Albrecht & Ewing, 1988; Duda & Allison, 1990) and subjects did not seek clarification on any of the changed items. Gauvin & Russell (1993) have argued that where no differences are expected in relation to culturally adapted items and the language of the test is the same, it is likely the test will remain valid. However, problems were still encountered in interpreting other original POMS items and explanations were often sought by boxers. For instance, the items *listless* and *bewildered* often needed further explanation. Interestingly, both these items have previously been identified as potentially problematic for athletes (Butler & Hardy, 1992; Terry, 1995).

McNair et al. (1971) have proposed that if a subject fails to understand more than one or two POMS items, it may suggest a language or intellectual problem exists. These remaining interpretation problems may suggest that the results of this study should be read with a degree of caution. Furthermore, it must be recognised that varying levels of incomprehension of POMS or other psychometric inventories may adversely affect the psychometric properties of the inventory (Anastasi, 1976; McNair et al.,1971; Weinberg & Gould, 1995). These potential problems indicate that further research monitoring mood states in amateur boxing training would benefit from the development of a more suitable instrument for use with boxers.

In summary, this study provides evidence to support anecdotal accounts of mood disturbance during intense boxing training. Furthermore, while no clear indications of overtraining were present, the mood changes seen in some individuals suggest amateur boxing training programmes could leave boxers at risk of overtraining and would therefore benefit from mood state monitoring via a more sport and culturally specific inventory.

Gauvin and Russell (1993) have eloquently argued the merits and justifications for sport/exercise specific versus nonspecific tests in sport science research. In their review of issues and strategies surrounding the development of psychometric tests, it was suggested that before test construction took place it was necessary to consider the foci of the research. If the primary goal was to understand some unique aspect of sport or group and that aspect bears little relevance to human behaviour more generally, then it was considered a sport specific test was more applicable (Gauvin & Russell, 1993). It was considered that this research programme was of an applied nature, and hence the development of a specific monitoring tool was justified to offer the opportunity for closer understanding of a boxer's experience of intensive training. The development of such an inventory is described in experiment 2.

Chapter 4

Experiment 2:

Development of a Boxing Modified and Shortened Profile of Mood States

Introduction

The POMS has been utilised in many previous investigations in an attempt to assess transient, distinct mood states. One of the major advantages in using the POMS is the ease of administration, with the completion of the questionnaire taking between three to five minutes in a normal healthy population (McNair et al., 1971). Nevertheless, Schacham (1983) noted that there may be situations where greater economy of assessment is desirable, such as when administering the POMS to very ill patients.

Schacham (1983) proceeded to develop a shorter version of the POMS. Eighty-three cancer patients were administered a reduced item POMS and internal consistency (coefficient alpha) and the item's face validity were used as criteria for elimination. The number of items was reduced from 65 to 37 and correlation coefficients between the short and original scales were all above .95. The author concluded that the short version was suitable for estimating the original mood state scores in the population used.

However, previous research using the POMS in sport and exercise has relied almost exclusively on the original 65 item questionnaire (Terry, 1995). Since sport researchers must often deal with situational restrictions on data collection, Grove and Prapavessis (1992) recognised the need for a shorter, modified version of the POMS. These authors proposed that an abbreviated version could be useful for data collection immediately after exercise when rapid physiological and psychological recovery is expected to occur. Furthermore, it was suggested a modified version could avoid needless repetition when multiple assessments are required.

In constructing another shortened POMS, Grove and Prapavessis (1992) used Schacham's (1983) version as a starting point, but made minor changes in the interest of brevity and comprehensiveness. Additionally, several esteem-related items were included in an effort to tap an extra positive dimension of emotion not usually assessed by the POMS. The reliability of the modified 40 item scale was evaluated by examining internal consistency coefficients and item-total correlations. Validity was assessed by comparing post competition winners and losers on total mood disturbance as well as on individual subscales.

Using a sample of 45 female netball players, Grove and Prapavessis (1992) found their version of the modified POMS demonstrated acceptable psychometric properties when administered to athletes immediately after performance. In terms of internal consistency, coefficients for the seven subscales ranged from .954 for fatigue to .664 for depression with a mean of .798. There was also evidence of subscale validity with significant differences across winning and losing outcomes on all scales except fatigue. The authors also proposed that further reductions in item content could be made to the POMS without necessarily affecting the internal consistency of the instrument.

Despite the proposed benefits of using a shortened version of the POMS where research designs require repeated measures to be taken, researchers in the overtraining field have rarely used a shortened format. Fry et al. (1994) used the 40 item Grove and Prapavessis (1992) version and found changes in vigor and fatigue over time. Interestingly, the newly added esteem scale showed no changes over a running training programme. Taking into account this finding, and the fact that the esteem scale has not been the subject of empirical research, it seems there is little rationale for monitoring an esteem-related mood when assessing athletes for symptoms of overtraining.

Raglin et al. (1995) also report use of a modified 30 item POMS (McNair, Lorr & Dropplemann, 1992) during a training study. Validation research had indicated that the reliability of the 30 item instrument compared favourably with the original 65 item set, with coefficients (Cronbach's alpha) ranging from .67 to .93 in college age samples (McNair et al., 1992). Raglin et al. (1995) found mood changes in several subscales during basketball training and concluded that the shortened POMS provided reasonable sensitivity for use in research of this type.

In summary, researchers have identified the need for a shortened, modified version of the POMS, yet despite the potential value of this format for monitoring training responses in athletes, few studies have utilised the available instruments. It is also clear from monitoring boxers with the original 65 item version, that problems were encountered in terms of some subjects' understanding of several items and also the sociocultural aspects of some POMS items required that slight modifications were made. Authors have recognised the need for culturally specific POMS checklists (Burglund & Safstrom, 1994; Grove & Prapavessis, 1992; Man & Krejci, 1985) and sport specific tests (Gauvin & Russell, 1993), hence changes to the original POMS may be warranted when using different populations (Albrecht & Ewing, 1988; Terry, 1995). Additionally, Terry, Keohane and Lane (1995) recently recognised the need for population specific research tools in presenting preliminary evidence for a POMS suitable for use with young (school age) athletes.

Suitably, in order to monitor boxers for psychological signs of training stress or overtraining, it seems necessary that a psychometrically sound shortened tool is developed which is relevant to the individual boxer, and also takes into account the cultural differences which may exist between a British sample and athletes from other countries. Cross-cultural differences in athletic populations have been found in previous sport science research (Chelladurai, Imamura, Yagamuchi, Oinuma & Miyauchi, 1987; Chelladurai, Malloy, Imamura & Yagamuchi, 1988; Torki, 1993), hence a culturally specific tool may be advantageous.

Furthermore, previous studies using the POMS to monitor for overtraining have found no changes in the confusion scale over training periods (e.g. Morgan et al., 1987; Raglin et al., 1995). The finding that no change in confusion occurred across boxing training suggests that this mood subscale does not warrant inclusion in any modified, shortened version of the POMS designed for monitoring purposes.

Anastasi (1976) and Brislin (1980) have suggested that the reliability and validity of a culturally adapted inventory should be tested in the target cultural group before using the measure in research. Anastasi (1976) described a process whereby a bank of items should be identified that have relevance for the target cultural population, but are also conceptually equivalent to the original set of testing items. The next stage in the development process requires the chosen items be tested with a pilot sample of subjects and assessed to the degree to which the internal consistency and statistical structure of the original item set has been maintained, if the test is to remain valid. Hence, the structure of the adapted inventory must be evaluated statistically with a culturally appropriate sample.

Therefore, this study examined the internal reliability of an abbreviated version of the POMS, which would be suitable for use with British boxers, and measures the five mood states vigor, fatigue, tension, depression and anger. The modified 40 item version (minus esteem and confusion scales) developed by Grove and Prapavessis (1992) was used as a starting point due to its construction for use with athletes and its sound psychometric properties. The procedures of establishing internal consistency (coefficient alpha) and item-total correlations adopted by Grove and Prapavessis (1992) were used to assess the psychometric properties of the new instrument.

Method

Pilot Work of Item Identification

The pilot phase consisted of identifying cultural and population specific items for inclusion in a new boxing modified, shortened POMS. For this purpose, 12 Royal Navy boxers took part in a word association exercise. Individually, boxers were read an adjective representing each mood state. Each boxer was supplied with items from the subscales of Grove and Prapavessis (1992) shortened version (minus confusion and esteem subscales, see items in table 4.1) and asked which items were considered by that individual to be most closely related to their understanding of the original item. Boxers were also supplied with the items included in the modified original POMS and asked whether these words identified closely with previous items. In all, boxers were supplied with ten items from each subscale. Finally, boxers were also encouraged to supply other adjectives which they felt were of the same or similar meaning to the previously identified items. When all boxers had completed the task, the items pertaining to each mood state were tallied to identify the most frequently occurring items in each subscale. A pre-determined criterion was established whereby an item had to be identified by each boxer in order to be included in the new shortened POMS. This criteria was selected as it was considered identification of an item by all of the group would deem the item appropriate for inclusion. In total, 22 items across the five subscales met this criterion.

Table 4.1: Items included in Grove and Prapavessis' (1992) Shortened POMS

VIGOR	FATIGUE	DEPRESSION	ANGER	TENSION
Cheerful	Worn Out	Hopeless	Peeved	Restless
Vigorous	Weary	Helpless	Bitter	Nervous
Full of Pep	Bushed	Sad	Resentful	On Edge
Active	Fatigued	Worthless	Grouchy	Tense
Energetic	Exhausted	Miserable	Angry	Uneasy
Lively		Discouraged	Furious	Anxious
			Annoyed	

Psychometric Properties of the Boxing Modified POMS

Participants

Participants in the study were 36 adult male amateur boxers from the West Sussex/Hampshire region. All boxers were actively involved in training and competition and fell into the three existing categories for senior boxers (novice, intermediate and open). The age range was between 18 and 30.

Instrument

The questionnaire used in this study was a modified, shortened version of the POMS. This 22 item (5 subscales) abbreviated version included various cultural and population specific items determined through pilot work with boxers. This modified version retained the standard five point format used in the original POMS. Responses ranged from 0 (not at all) to 4 (extremely) and the instructional set "past week including today" was used. Item number 14 (Relaxed) on the tension subscale was reverse scored.

Procedure

Coaches and boxers were contacted by telephone and visited in person to explain the project and to request their co-operation. Boxers agreeing to participate were then asked to complete the modified POMS following one of their training sessions. Questionnaires were handed to the boxers after training and collected as soon as the boxers had completed them. Confidentiality was assured and testing was carried out over a two week period during the boxing season.

Results

Subscale Relationships and Item-Total Correlations

Initially, correlations were completed between individual items and the total score on each of the five subscales. Table 4.2 contains these correlations and provides information about relationships amongst the subscales as well as relationships among specific items and the various subscales.

Table 4.2. Correlations Among Items and Subscales in the Boxing Modified POMS

Sub-scale & Item	FATIGUE	ANGER	VIGOR	TENSION	DEPRESSION
FATIGUE	1.00	.66	-.71	.08	.54
Worn Out	.89	.55	-.74	-.24	.50
Tired	.85	.50	-.68	-.14	.47
Need a Rest	.89	.60	-.69	-.08	.39
Fatigued	.82	.41	-.59	.03	.37
Drained	.50	.25	-.17	.30	.31
ANGER	.66	1.00	-.38	.06	.48
Angry	.63	.73	-.28	.11	.60
Annoyed	.49	.82	-.26	.02	.50
Bad-Tempered	.51	.61	-.43	.09	.26
Irritable	.30	.65	-.20	-.03	.31
VIGOR	-.71	-.38	1.00	.22	-.37
Alert	-.60	-.25	.91	.44	-.36
Active	-.54	-.20	.86	.33	-.25
Lively	-.67	-.38	.83	.24	-.44
Energetic	-.78	-.36	.88	.19	-.48
TENSION	.08	.06	.22	1.00	-.21
Tense	-.16	-.15	.32	.79	-.42
Worried	-.02	-.08	.21	.72	-.33
Anxious	-.09	-.11	.25	.87	-.39
On Edge	.01	.17	.27	.73	-.19
Relaxed	.19	.11	.10	.75	.10
DEPRESSION	.54	.48	-.37	-.21	1.00
Sad	.46	.47	-.30	-.20	.85
Miserable	.53	.46	-.40	-.25	.86
Down	.52	.47	-.31	-.11	.89
Unhappy	.33	.13	-.23	-.34	.84

Examination of the subscale intercorrelations showed three general sets of subscales. The first set contained three negative mood subscales (depression, anger, fatigue) which correlated moderately with each other. The range of r values between these subscales was from .48 to .65, suggesting similarity but not replication amongst these mood states.

The second set consisted of the fourth negative mood subscale, tension, which did not appear to exhibit the same relationship with the first set noted above. Correlations between this and other subscales ranged from -.21 to .22 suggesting this measure was unrelated to other mood dimensions.

The third set appeared to be the vigor subscale. Correlations between the positive mood subscale and the four negative mood subscales ranged from -.71 (fatigue) to .22 (tension), which seemed to suggest vigor as an independent subscale, with negative relationships seen with three of the four negative emotion subscales.

Close examination of the item-total correlations in table 4.2 suggests that all the items exhibited higher correlations with their own preassigned subscale than with other subscales. Indeed, out of all the subscales, only the one item, drained (included on fatigue subscale), seemed to show a poor relationship in comparison with other items on the same subscale (r=.50 compared with other four fatigue items ranging from .82 to .89). However, the same item did not appear to show a strong relationship with any of the other subscales with correlations ranging from -.17 to .31.

Additionally, two items on the anger subscale demonstrated similar correlations with other subscales. For instance, the item bad-tempered revealed a correlation of .61 with its own subscale, whilst also showing a .51 relationship with the fatigue subscale. Likewise, while the item angry exhibited a stronger .71 correlation with its specified subscale, it also showed close correlations (.63 and .60) with the fatigue and depression subscales respectively.

Subscale Reliability and Item Analysis

Internal consistencies were determined for each of the five subscales by calculating alpha via the Statistical Package for the Social Sciences. These coefficients are shown in the second column of table 3 and range from .93 for depression to .72 for anger, with a mean of .86.

Reliability analyses were also conducted on the individual items of the shortened POMS. The extent to which each item formed an important part of its respective subscale was assessed by calculating the subscale alpha with that item omitted. These can be seen in table 4.3 in the fourth column. In all subscales the deletion of items resulted in lower alpha coefficients, with the exception of the items drained and bad-tempered on the fatigue and anger subscales respectively. Removal of these items increased the subscale alphas from .85 to .92 (fatigue) and from .72 to .73 (anger).

Table 4.3. Internal Consistencies for Subscales and Items in the Boxing Modified POMS

Subscale	Mean Alpha For Subscale	Item	Mean Alpha if Item Deleted
FATIGUE	.85	Worn Out	.79
		Tired	.81
		Need a Rest	.78
		Fatigued	.81
		Drained	.92
ANGER	.72	Angry	.62
		Annoyed	.67
		Bad-Tempered	.73
		Irritable	.61
VIGOR	.90	Alert	.84
		Active	.89
		Lively	.88
		Energetic	.87
TENSION	.90	Tense	.86
		Worried	.88
		Anxious	.85
		On Edge	.88
		Relaxed	.90
DEPRESSION	.93	Sad	.90
		Miserable	.91
		Down	.89
		Unhappy	.93

Discussion

These findings suggest that the modified POMS developed for use with British boxers has acceptable psychometric properties. The correlations between subscales indicate some moderate relationships, but independence for each subscale and all the items in the modified POMS appeared to contribute appropriately to their respective subscales. Furthermore, the internal consistencies found show alpha coefficients which were very high for depression, tension, vigor and fatigue and moderately high for anger.

The version of the POMS developed in this study seems to compare favourably with previous attempts to shorten the questionnaire. According to Anastasi (1976) the internal consistencies and statistical structure of the adapted inventory must be maintained if the test is to remain valid. The range of internal consistencies seen here (.72 to .93) are similar to those cited by Schacham (1983) .73 to .91, Grove and Prapavessis (1992) .66 to .95, and McNair et al. (1992) .67 to .93. The sound psychometric properties found in this study support the assertion by Grove and Prapavessis (1992) that a further reduction in the number of items in each subscale would not have detrimental effects on the internal consistencies of the mood subscales. The five subscales measured in this study consisted of 22 items in comparison with 30 items in the same subscales reported by Grove and Prapavessis (1992).

Furthermore, the mean alphas reported in this study support the work of Schacham (1983) and the original work of McNair et al. (1971) who found depression to have the highest internal consistency relative to other subscales. This is in contrast to Grove and Prapavessis (1992) and McNair et al. (1992) who both found the fatigue subscale to display the greatest alpha coefficient in their shortened POMS versions.

The item *drained* on the fatigue subscale was the only adjective which appeared to tap a slightly different aspect of emotion than the other items on that subscale or the other subscales in general. The same item's negative effect on the fatigue subscale's internal consistency also points to a problem when including this item to assess fatigue related affect in boxers. The adjective was one generated through pilot work with boxers and was hoped would add strength to a cultural and population specific instrument. However, it appears this item has not been associated consistently with fatigue in the present study. In the domain of sport sociology, Coakley (1994) has documented the concept of sport subcultures and the use of group specific language and behaviours, hence the item *drained* may reflect usage specific to the group upon which pilot work was based. While the item does not seem to contribute more strongly to other mood dimensions, its demonstrated psychometric weakness suggests that further research using the modified instrument may benefit from its elimination.

The anger subscale may also contain some items which contribute to other subscales. Whilst the items bad-tempered and angry correlate most strongly to the anger subscale, they also demonstrated similar relationships with the fatigue and depression subscales suggesting some association with these negative mood states. With pilot work identifying just four items on the anger subscale, it seems further modification is problematic. However, despite the anger subscale showing the weakest overall internal consistency, it is suggested that a .72 alpha represents a coherent, acceptable subscale suitable for further use in monitoring boxers for anger related affect.

Duda and Allison (1990) and Gauvin and Russell (1993) have previously discussed the importance of culturally specific psychometric inventories. The shortened version of the POMS developed by Grove and Prapavessis (1992) was used as an initial framework for establishing a culturally specific British format, hence a comparison of the item content of subscales would enable a reflection of how athletes in different cultures may require different words to assist interpretation and completion of the POMS.

Examination of the five subscales used in developing a new modified POMS reveals that 12 of the 22 included items also appear in the Grove and Prapavessis (1992) version. For instance, on the fatigue subscale, the items *fatigued* and *worn out* are shown to be suitable for interpretation across the Australian, North American and British cultures. However, new inclusions on this subscale are the items *tired* and *need a rest* to replace items such as *bushed* and *weary*. Likewise, on the depression subscale, *sad* and *miserable* have been retained, whilst the new item *down* was identified through pilot work, and the item *unhappy* also appears on the original 65-item POMS. The identification and inclusion of the adjective *down* further supports the decision to include this item to replace the item *blue* in the first study monitoring boxers' moods during training. Similarly, in the vigor subscale, the item *full of pep* was, as expected, not selected in pilot work, whereas the pilot generated item *alert* has previously appeared on the original POMS 65 item adjective checklist.

In conclusion, it appears the present instrument offers a brief, psychometrically sound measure of positive and negative mood. Whilst it is recognised that no norms exist for this shortened version or whether it is applicable for use by other British athletes, it seems that the modified POMS may be a suitable tool for monitoring training stress in British amateur boxers. To establish the validity of the inventory for monitoring purposes, changes in various mood states should be detectable through its use by boxers undergoing intensified training. This is examined in experiment 3a. The interdisciplinary nature of the project also begins, with an integrated investigation into S-IgA in boxers.

Chapter 5

Experiment 3a:

Mood State and S-IgA Across a Boxing Season

Introduction

The review of literature earlier in this thesis documented a great deal of research which has focused on the S-IgA response to exercise, and also highlighted the potential for the innate immune system to be compromised through exercise. The specific types of exercise that were deemed to be problematic were those involving heavy training schedules and also interval type training. Amateur boxing training regularly involves high intensity interval sessions and heavy training loads, and anecdotal evidence suggests boxers most frequently suffer from infections in these periods (Kelvin Travis, ABA Staff Coach, personal communication, 1994). Hence, when considering the link between S-IgA and the onset of URTI (MacKinnon et al., 1993a), it would seem that the most likely period where S-IgA suppression may occur is in a period of heavy/interval type training.

The demands of amateur boxing and the environmental factors surrounding the sport must also be considered. Such factors may adversely affect the innate immune response of boxers and could increase the rate of transmission of infections thus leaving the boxer more susceptible to URTI. For instance, the weight classified nature of boxing frequently requires boxers to restrict food and fluid intake during training in order to compete at a competition weight (Smith, 1993). It is commonplace to find boxers in a dehydrated state during intense training if they are struggling to decrease body weight with a competition approaching. Evidence of impaired phagocytic immune system functioning during periods of low calorific intake and weight reduction in athletes has been presented by Kono, Kitao, Matsuda, Fukushima and Kash (1988). The effects of dehydration on saliva flow have also been documented (Kerr, 1961), and hence it may be that boxers could dramatically reduce innate protection against URTI through reduced saliva (and its inbuilt protector mechanisms) lining the mucosal surfaces.

The potential for communicability and transmission of URTI within sport has been addressed by Weidner (1994). A review of this paper suggests environmental factors in boxing may also leave the individual more susceptible to infection. The close contact nature of the sport may increase transmission of viruses through glove to body or skin to skin body contact. The sharing of contaminated equipment by athletes may also increase infection rates (Weidner, 1994). Notably, gloves, punch bags and sweat suits are commonly shared by boxers in training. Transmission may also be facilitated when boxers clear their respiratory passages. Spit buckets are often found in the corners of boxing rings and these may be involved in spreading infected mucous. Cannon (1993) has suggested that interpersonal exchanges in contact sports, crowded changing environments and the sharing of drinks containers all enhance transmission of infectious micro-organisms. Therefore, the apparent prevalence of URTI symptoms coupled with the potential for transmission in boxers, the lack of research documenting the S-IgA or innate immune system response in boxing, and the possibility of S-IgA links with training stress provides the rationale for further addressing the immune response in amateur boxing training.

The study of the immune response to boxing may identify a need for the implementation of practical strategies to reduce any susceptibility to infection in boxers. If reduced immune function were found during training periods, it may be that increased organised care is required to reduce the opportunity for transmission in the environment during this phase of the training cycle. Preventative measures identified by Shephard and Shek (1993) include minimising exposure to pathogens, monitoring of the training plan, and maintaining an adequate diet.

Finally, the review of literature presented earlier cited an abundance of monodisciplinary literature which has documented mood states and S-IgA levels during training phases. It is evident that with the exception of experiment 1, amateur boxing appears to represent a void in monodisciplinary investigations of this nature. It is equally clear that no studies appear to have followed the S-IgA and mood state response over a season, and sought to examine the relationship between the measures. Combining the findings from experiment 1 indicating mood disturbances in boxers, the anecdotal evidence suggesting increased incidence of infections in boxers during heavy training, plus the findings of previous sport science literature on exercise and the S-IgA response, it seemed logical and appropriate to simultaneously examine both measures during boxing training.

It was hypothesised that there would be evidence of reduced S-IgA in boxers in a period of heavy training. It was also considered likely that there may be evidence of reduced saliva flow in the heavy training period, which would also affect innate immune system defences. The modified POMS was also expected to demonstrate mood disturbances in a heavy training period. However, it was unclear whether any relationships would be found between psychological and immunological measures.

Method

Participants

The participants were eight amateur boxers, (mean±SD) age 22±2.8 years, who were members of the Royal Navy Boxing Squad based at H.M.S. Nelson in Portsmouth, Hampshire. The Royal Navy coach and all participants were informed of the nature of the study and gave written consent to participate.

Instrumentation

The questionnaire used in this study was a boxing modified, shortened version of the POMS (Mc Nair et al., 1971). This 21 item version assessed five subscales of mood state; vigor, fatigue, tension, anger and depression. Four items were included on each subscale, with the exception of tension which contained five items. Responses ranged from 0 (not at all) to 4 (extremely) and the standard instructional set "last week including today" was used.

Protocol

The mood state and S-IgA response to boxing training was assessed on three occasions over a competitive season; early season (light intensity, October), mid season (high intensity, December) and late season (medium intensity, February). The POMS was administered to boxers and saliva collected on one occasion at each training intensity. Data collection took place at 8 a.m. before the first training session of the day.

The training intensities formed part of the boxers' normal training programmes and were subjectively defined by the Royal Navy coach. The content of the training intensities was also independently scrutinised and accepted by the Amateur Boxing Association (BASES

Accredited) exercise physiologist. Since this research was interested in boxers undergoing normal training, no attempt was made to alter the training as set by the coach. Examples of the training sessions undertaken at each training phase are seen in table 5.1.

Table 5.1. Training Regimes at Data Collection Points

October (Low Intensity)	December (High Intensity)	February (Med. Intensity)
(2-3 sessions per day)	(4-6 sessions per day)	(3-4 sessions per day)
4 mile steady run	5 mile steady run	5 mile steady run
Gym Session (6*3min.)	Interval runs (4*400,3*200,2*100m)	Interval run (6*200m)
Technique session	Conditioned & Open Sparring	Technique session
Flexibility session	Gym Session(8*3min.)	Flexibility session
Fixed load circuit (10 ex*10 rep*1 lap)	Fixed load circuit (3-4 laps)	Fixed load circuit (2 laps)
Free Weights	Target circuit (2-3 laps)	Target circuit (8 stations*30 sec.*1 lap)
	Interval Gym work (16*1min.)	Gym session (6x3min.)
	Fartlek running	

Note: The daily programmes at each training phase would incorporate some of the sessions noted above, as well as boxing specific drills and exercises.

Saliva Collections

The standardised timing of the sessions minimized the influence of circadian rhythms in salivary flow and composition (Dawes, 1974). The unstimulated saliva collection procedures were consistent with those used in recent research by MacKinnon and associates (MacKinnon et al., 1993 a, b; Mackinnon & Jenkins, 1993; MacKinnon & Hooper, 1994) and allowed for the collection of naturally occurring saliva without the confounding influence of artificial stimulation. The participants were asked to follow their normal routine prior to saliva collections. Immediately prior to collection, participants rinsed their mouths thoroughly with water. Whole unstimulated saliva was then collected for four minutes in 10 ml Medfor Products plastic tubes. The participants were asked not to swallow during saliva collection but were free to expel saliva at their own rate. The saliva collections were immediately frozen at -20°C, transported frozen to the laboratory and stored at -70°C until assayed.

Saliva Analysis

The volume of saliva produced was determined by weighing the defrosted saliva, with Ohaus E120 scales (C.V. 0.09%, readable to 0.01g). Saliva consists of 99.5% water and the specific gravity of saliva is believed to vary between 1.000 and 1.010 (Kerr, 1961; Miletic et al.,1996; Schouten et al., 1988). Saliva volumes can therefore be determined by weight, and Mason and Chisholm (1975) have recommended the weighing of saliva to calculate volume as opposed to use of a pipette. After the mass of the collection vial had been subtracted, the mass in grammes was divided by the collection time (four minutes) to determine flow rate ($ml.min^{-1}$). The samples were then centrifuged at 2000rpm for 10 minutes with a Sanyo (2-15) centrifuge. The supernatant was drawn off for S-IgA analysis with enzyme-linked immunosorbant assay (ELISA, Engvall & Perlmann, 1972).

ELISA is carried out by a process of sequential addition of the assay components into wells in a plastic microtitre plate. Each stage is incubated at a pre-determined temperature for a specific time in order for the required interactions to develop. For the measurement of S-IgA, a capture antibody, specific for the Immunoglobulin being measured is physically adsorbed to the wells of a microtitre plate. Unadsorbed antibody is then removed by emptying the plate wells and then washing the plate with a phosphate buffered saline solution. A blocking protein is then added and adsorbed onto any plastic inside the wells not coated with capture antibody. This is to prevent following phases of the assay binding non-specifically to the plate and not to the capture antibody. Again the unbound fraction is washed off. The next sequence involves adding the diluted biological samples to the wells. During the ensuing incubation period, this binds to the capture antibody. Any unbound sample is washed off. A detector antibody is then added, which is again specific to the Ig being measured. This antibody is conjugated to an enzyme. The unbound fraction is washed off. Finally, the conjugated enzyme's substrate is added. The ensuing reaction generates a coloured product, of which the optical density can be quantified by photometry.

Assay Procedure

A 96-well polystyrene plate (Greiner Laboratechnik, UK) was coated with anti-IgA antibody (Sigma I-8760), diluted 1:800 in coating buffer, by adding 100μl to each well. The plate was then incubated for 1hr at 37°C. After this point disposable face masks (Hospital management supplies, UK) were worn whenever handling the plate to avoid contamination of the plates with aspirated saliva.

After incubation the plates were then blotted and washed five times with PBS-Tween-80 (washing buffer). The 'blocking' solution was made (2% solution of dried skimmed milk, and phosphate buffered saline), and 100μl added to the coated wells (except control wells). The plate was again incubated for 1hr at 37°C, in a humid chamber.

The plate was again blotted and washed five times with PBS-Tween-80. Serially diluted human serum IgA (Sigma), in the following concentrations, 0.5, 1, 2.5, 5, 7.5, 10μgml^{-1} was added in duplicate to the desired wells. Saliva samples were diluted 1:100 with distilled and deionised water, 100μl was added in duplicate to the desired wells. After addition of the samples the plates were incubated for 1hr at 37°C.

The blotting and washing procedure was repeated with PBS-Tween-80. Anti-human IgA horseradish peroxidase conjugate was diluted 1:1000 in 'blocking' solution and 100μl of this secondary antibody solution was added to each well. The plates were incubated again for 1hr at 37°C.

The washing procedure was repeated again with PBS-Tween-80. The enzyme substrate solution was made by dissolving a 10mg 2,2'-Azino-Bis (3-Ethylbenzthiazoline-6-Sulfonic Acid) tablet (Sigma) in 20ml of citrate buffer, and adding 5μl of 30% w/v hydrogen peroxide. The enzyme substrate solution was added to the plate by pipetting 50μl into the wells across the plate. The plate was then incubated at room temperature for fifteen minutes before the absorbance was read at a wavelength of 414nm using a Multiscan 310 plate reader (Biological instrumentation service Ltd., UK).

All of the samples were assayed in duplicate, and regression analysis using the relationship of standard IgA concentrations and amount of absorbance was used to interpolate the S-IgA concentration ($\mu g.ml.^{-1}$) in the samples. The standard curve of concentration on absorbance resulted in a coefficient of determination of $r^2 = .94$. Reliability data for the 24 duplicate samples indicated that there was no significant difference ($p>0.05$).

For analysis purposes, data was expressed in three ways:

a) Absolute concentration of IgA (S-IgA conc.) as measured directly in the ELISA ($\mu g.ml.^{-1}$).

b) Saliva flow rate ($ml.min^{-1}$), calculated by dividing the total volume of saliva (ml) collected in a sample by the time taken to produce the sample (4 min.).

c) S-IgA secretion rate ($\mu g.min.^{-1}$) or the total amount of IgA (μg) appearing on the mucosal surfaces per unit of time (min.). This was calculated by multiplying absolute IgA concentration ($\mu g.ml^{-1}$) with saliva flow rate ($ml.min.^{-1}$).

Results

Mood States

Means and standard deviations for the mood subscales at each training intensity are presented in table 5.2.

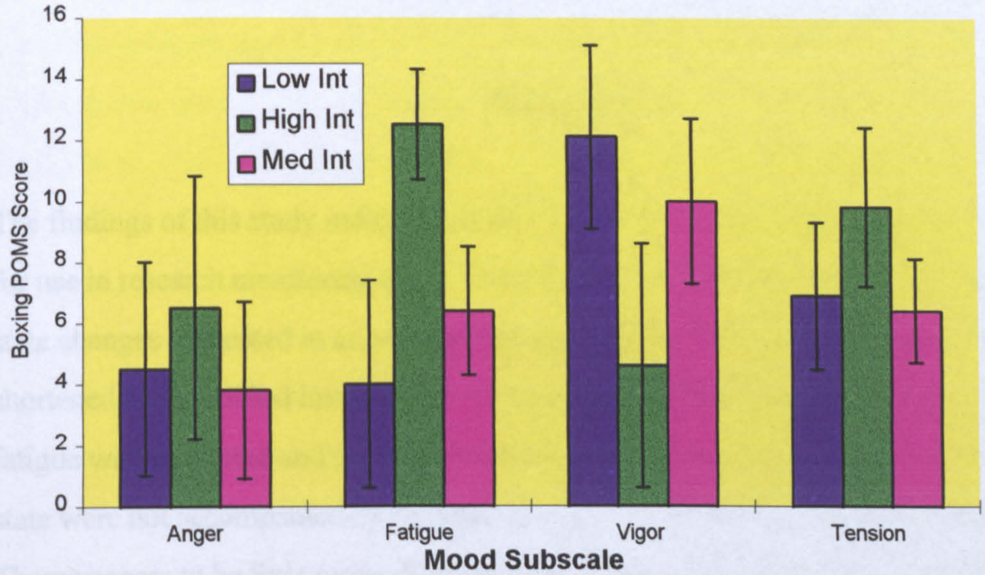
Table 5.2. Mean values (±SD) for POMS Subscales Across Training Intensities

MOOD & SCALE RANGE	LOW INTENSITY	HIGH INTENSITY	MEDIUM INTENSITY
Anger (0-16)	4.5 (3.5)	6.5 (4.3)	3.8 (2.9)
Fatigue (0-16)	4.0 (3.4)	12.5 (3.3)	6.4 (3.9)
Vigor (0-16)	12.1 (3.0)	4.6 (1.8)	10.0 (2.1)
Depression (0-16)	4.6 (1.8)	4.1 (4.0)	3.1 (2.7)
Tension (0-20)	6.9 (2.4)	9.8 (2.6)	6.4 (1.7)

A series of one-way Repeated Measures ANOVA, with time as the repeated measure, revealed differences in tension ($F_{2,14}$ = 6.45, p<0.01), anger ($F_{2,14}$ = 6.47, p<0.01), vigor ($F_{2,14}$ = 82.65, p<0.001) and fatigue ($F_{2,14}$ = 24.79, p<0.001). Post hoc Tukey tests showed tension, vigor and fatigue exhibited negative shifts in the high intensity training phase. Vigor exhibited significant positive shifts towards the light intensity levels during the medium intensity training period, while fatigue and tension returned to the light intensity levels. Anger was significantly lower during final training phase compared with the light and high intensity periods. There were no differences between training intensities in the depression subscale. The above changes can be seen in figure 5.1.

Figure 5.1.

Mood State Changes Across Training Intensities



S-IgA

S-IgA concentrations, S-IgA secretion rates and saliva flow rates were calculated for each of the three data collection points. Means and standard errors can be seen in table 5.3.

Table 5.3.

S-IgA Concentrations, S-IgA Secretion Rates and Saliva Flow Rates (mean±SEM.)

MEASURE	LOW INT.	HIGH INT.	MEDIUM INT.
S-IgA conc.(μg.ml.$^{-1}$)	412 (54)	373 (53)	429 (69)
Saliva flow (ml.min^{-1})	0.62 (0.07)	0.64 (0.07)	0.67 (0.06)
S-IgA sec. (μg.min.$^{-1}$)	253 (44)	226 (30)	312 (59)

A one-way Repeated Measures MANOVA showed no significant effect for TIME, λ= 0.34 ($F_{2,6}$ = 0.63, p>0.05). S-IgA concentration and saliva flow showed a non-significant negative relationship (r=-.18, p>0.05).

Pearson correlations were used to examine the relationship between individual mood state subscales and S-IgA concentration, S-IgA secretion rate and saliva flow. These analyses showed non-significant relationships ($p>0.05$).

Discussion

The findings of this study indicate that the 21-item POMS provides reasonable sensitivity for use in research monitoring mood disturbances in boxers during training. The mood state changes witnessed in experiment one were replicated to a large degree, showing the shortened and modified inventory was able to discriminate changes in tension, vigor and fatigue with increased and decreased training loads. However, these changes in mood state were not accompanied by changes in S-IgA in boxers over the competitive season. There appears to be little research in sport which has documented S-IgA levels over a season, hence this research seems to provide preliminary evidence of a longitudinal study of this duration.

The results of this study on S-IgA in boxers does not support the work of Tharp and Barnes (1990), who found significant decreases in S-IgA over a three month period of swim training. In contrast, this study confirms the results of Tharp and Barnes (1990) concerning the relationship between mood and S-IgA. No significant relationships were found between S-IgA concentrations or secretion rate and any of the five mood states that were measured. MacKinnon and Hooper (1994) have mentioned unpublished evidence of a relationship between individual mood states and decreases in S-IgA in swimmers, however the results of this study on amateur boxers does not suggest such an association.

The finding that the mood state anger was elevated during the medium intensity period does not support the results of experiment one monitoring mood states during amateur boxing training. It had been suggested that the close interaction between individuals in combat sport training may have led to increases in anger related affect. There are two possible explanations for the different results found in this study. Firstly, a different group of boxers were used in experiment one, and hence individual differences in mood responses to training (Morgan et al., 1987) may have influenced the results. Secondly, whilst experiment one used the original POMS to monitor for mood state changes in amateur boxers undergoing training, this experiment utilised the boxing modified, shortened version. It has been documented that the anger subscale showed the weakest alpha (.72) in the latter version, and therefore the differences found across experiments in the anger subscale may be due to the use of different psychometric inventories. Suitably, with only two previous studies documenting increases in anger (Murphy et al., 1990; Raglin et al., 1991), it seems this mood response to increased training is still unclear.

The non-significant changes in S-IgA in this study imply that this aspect of acquired immune system functioning is not compromised in boxers during differing training loads. However, the extreme inter-individual variability in S-IgA measures (Kugler, 1991) were evident in this study, with a wide range of values registered within the sample of boxers at each data collection point. Likewise, whilst there were no mean changes in S-IgA concentrations or secretion rate over the season, there was evidence that the magnitude of the response varied considerably between the boxers. For instance, comparing the S-IgA secretion rate values of two boxers from the low intensity to high intensity period showed one individual to show a 50% increase, whilst the other decreased by 43%. McDowell et al. (1993) have previously noted this variability pattern, and it may be that the intensity of the training programme relative to the individual may have influenced the results of this study.

Perhaps the most interesting finding of the immunological data was the saliva flow rates found at each collection. MacKinnon & Jenkins (1993) have argued that saliva flow rates need to be considered to ascertain a more biologically relevant picture of the S-IgA and exercise relationship. However, MacKinnon and Jenkins (1993) argued for the inclusion of flow rate data due to its effects on S-IgA secretion, whereas the flow rates seen in this study are proposed to have profound effects on innate immune system functioning as well as IgA secretion.

The mean saliva flow rates in the present study (0.62-0.67 $ml.min^{-1}$) are substantially below the 1-2 ml. min^{-1} normal resting values documented by Rudney (1990). Sports training studies have rarely cited saliva flow data, however the investigation into S-IgA and weight-training by McDowell et al. (1993) reports similar flow rates

(1.2-1.9 ml.min^{-1}) to the normal values of Rudney (1990). Hence, it would appear that boxers exhibit unusually low saliva flow rates. Kerr (1961) has previously shown that dehydration can negatively affect saliva flow, and boxers may often train in a semi-dehydrated state particularly when competitions are approaching; a process known traditionally as "drying out". Prior to the commencement of the study it was thought that saliva flow, and hence S-IgA, could be compromised during periods of heavy training when boxers may be employing weight loss strategies for competition in tandem with heavy training schedules. However, Smith (1993) has suggested that weight maintenance for many boxers is an all year round problem and it could be that the saliva flow rates reported reflect varying degrees of dehydration which boxers may experience as a normal part of their training.

Further support that weight reduction may be central to the low saliva flow rates recorded in boxers is gained when comparing the flow rate data of the super-heavyweight (+91kg) included in this study. Boxers in this highest weight category do not have a weight restriction, and hence do not need to practice the common forms of weight management strategies seen in lighter weight categories. Flow rate data for this boxer showed values ranging between 1.06 and 1.08 ml.min^{-1}, which were substantially larger than all other boxers, and fall within the normal range of values cited by Rudney (1990).

Suitably, it appears that amateur boxers may suffer from chronically low saliva flow rates during the competitive season, perhaps as a result of constant weight maintenance and reduction linked to the weight-classified nature of the sport. Weight reduction has been shown to have detrimental effects on the innate immune system in athletes (Kono et al., 1988), although not on saliva flow. The potential effects of low saliva flow should not be underestimated, having important implications for a boxer's defences against URTI. Saliva has a mechanical washing action, sweeping potential pathogens into the hostile environment of the stomach (Smith, 1995), and is probably an important factor in the prevention of infection in the upper respiratory tract (Mason & Chisholm, 1975). Low saliva flow has been linked to increased URTI in non-athletes (Miletic et al., 1996), and a similar dry mouth condition known medically as xerostomia has also been associated with the incidence of URTI in young cancer patients (U.S.A. Dept.of Health, 1993). Additionally, the S-IgA response to invading pathogens can only be effective if physical contact is made with the pathogen, in which saliva fulfils a vital role. It has been highlighted that low saliva flow rates can adversely affect the quantity of S-IgA appearance on the mucosal surfaces (MacKinnon & Hooper, 1994) and reduced S-IgA has been associated with the onset of URTI (MacKinnon et al., 1993a).

It is evident however, that this study merely suggests that reduced saliva flow could lead to an increased risk of contracting infections rather than providing evidence of increased infection in boxers. Past epidemiological studies have been criticised for the methodological weakness of using different self-report symptom checklists (Weidner, 1994) and this study did not attempt to monitor the incidence of infection in boxers as self-report symptom checklists for URTI were deemed problematic. For instance, sore, dry and itchy throats are usually monitored via self-report (Heath et al., 1992), and boxers often complain of such symptoms. However, it is quite possible that the problem of a dry mouth linked to excessive or semi-dehydration and low saliva volumes in boxers could mistakenly be reported as a symptom of URTI. At best it would seem difficult for a boxer to distinguish between two similar conditions. Hence, the absence of the opportunity for physician confirmed infections suggested by Heath et al. (1992) prevented any investigation into incidence of URTI in boxers during the course of the investigation.

In conclusion, this study has shown the modified POMS to be sensitive to changes in mood resulting from differing training intensities. The non-significant changes in S-IgA measures during levels of boxing training suggest that the anecdotal evidence of infections in boxers during training may not be explained by changes in S-IgA over a season. However, the low saliva flow rates recorded in boxers indicates the possibility of impaired innate immune function.

The effects of different saliva collection protocols and their effects on the measurement of S-IgA was highlighted in the review of literature. This study followed the unstimulated, whole saliva collection procedures proposed by MacKinnon and associates (1993 a, b; 1994). However, Aufricht, Tenner, Salzer, Khoss, Wurst and Herkner (1992) have reported that there are other factors which may influence the volume of saliva collected. The method of asking subjects to passively dribble has been widely used (e.g. Green & Green, 1987; MacKinnon et al., 1993 a, 1993b, 1994; McDowell et al., 1992; Tomasi et al., 1982), whilst the salivette method used by Aufricht et al. (1992) requires subjects to place a cotton wool swab in the oral cavity, which is later centrifuged to remove the saliva for analysis. However, Aufricht et al. (1992) reported significantly higher saliva flow rates and indicated that salivettes may stimulate saliva flow.

Whilst many other studies do not report this aspect of saliva collection (e.g. McDowell et al., 1985; Schouten et al., 1988), the present study used the passive dribbling method. The values found in boxers have been compared to the normal values cited by Rudney (1990) and those reported by McDowell et al. (1993) in a weight-training study, both of which also employed the dribbling method. Nevertheless, saliva flow and composition is affected by circadian variation (Dawes, 1972) and the values cited by Rudney (1990) and McDowell et al. (1993) do not specify the exact time of collection. This could evidently lead to erroneous comparisons. Suitably, if it is to be argued that the resting saliva flow levels seen in boxers are unusually low, a comparison is needed with untrained, rested subjects controlling for the possibility of circadian rhythms. This is the subject of the investigation in experiment 3b.

Experiment 3b:

Resting Saliva Flow Rates in Sedentary Individuals

Introduction

Circadian variation in saliva flow and composition is reported by Dawes (1972). This suggests that for the purpose of comparison, a resting value in untrained subjects should control for the timing of saliva samples. Other factors also need to be considered and controlled. For instance, Miletic et al. (1996) have reported differences in saliva flow between young (20-30 years) and elderly (60-80 years) persons. This suggests that the flow rates seen in boxers need to be compared with an age-matched sample. Smoking has also been noted to affect saliva flow (Rudney, 1990), hence this variable also needs to be controlled.

Method

Participants

The participants in this study were eight male sport science undergraduate students. Selection criteria required students to be non-smokers, not participating in any physical training programme, and were also matched for age (mean±SD, 22±0.6 years) with the sample of boxers in the previous study. The participants were asked to follow their normal dietary pattern for the duration of the study.

Protocol

Saliva collections took place in the laboratory at 8 a.m. on three separate occasions at weekly intervals, and followed the collection procedures outlined in experiment 3a. The weighing of saliva was completed immediately, hence there was no need for the freezing of samples.

Results

Mean saliva flow rates (±SEM) across the three week period can be seen in table 5.4.

Table 5.4.

Saliva flow rates (mean±SEM.) in three week collection period (n=8)

MEASURE	Week 1	Week 2	Week 3
Saliva flow ($ml.min^{-1}$)	1.13 (.06)	1.08 (0.06)	1.16 (0.07)

Statistical analysis via a one-way Repeated Measures ANOVA, with time as the repeated measure, showed no significant difference between days ($F_{2,14} = 1.14$, $p>0.05$).

The saliva flow rates seen in sedentary participants were also compared with those of the boxers measured in the previous study through an independent t-test. Data at week two (sedentary participants) and the medium intensity training period (boxers in experiment 3a) showed a significant difference ($t_{14} = 5.44$, $p< 0.0001$), with boxers showing lower saliva flow rates. The time points selected for comparison were the lowest mean score for sedentary participants and the highest mean score for boxers.

Discussion

This brief investigation into saliva flow rates enables the comparison of flow rate data in boxers to values recorded in age-matched, rested, untrained male subjects, and also controls for the timing of samples. Subsequent analysis of the highest mean saliva flow rates in boxers and the lowest mean saliva flow seen in sedentary participants showed a significant difference, with boxers (0.67 $ml.min^{-1}$) exhibiting considerably lower flow rates than the sedentary group (1.08 $ml.min^{-1}$). This finding would seem to endorse the potential limitations to boxers innate immune system functioning which were outlined in experiment 3a.

Saliva secretion is believed to be principally controlled by the autonomic nervous system (Mason & Chisholm, 1975). The control of saliva flow seems to be primarily parasympathetic, with increased saliva flow achieved by increased blood flow to the salivary glands by vasodilation (Saracco & Crabbins, 1993). Sympathetic stimulation reduces blood flow via the vasoconstriction of arterioles within the saliva gland and subsequently saliva flow (Provenza & Siebel, 1986). The autonomic control of saliva flow has implications for exercising individuals.

During physical activity ventilation increases and this requires greater dependence on oral breathing to reduce resistance to the flow of air, and mouth breathing has been shown to result in oral drying (Powers & Howley, 1990). Saliva flow rate and volume has been shown to reduce considerably during exercise, probably as a result of increased sympathetic output (Pilardeau et al., 1990). This potential reduction in saliva flow during exercise has been recognised in more recent S-IgA studies (e.g. Mackinnon et al., 1993 a, b; Mackinnon & Jenkins, 1993; MacKinnon & Hooper, 1994; McDowell et al., 1993) and it is evident that the low resting saliva flow rates in boxers could be further compromised through increased sympathetic output within training sessions. Further decreases may limit or diminish the effectiveness of saliva as an innate defence, and could also restrict the levels of S-IgA appearing on the mucosal surfaces. This possibility is examined in experiment 4.

Chapter 6

Experiment 4:

The Effects of Repeated Amateur Boxing Interval Training on Saliva Flow and S-IgA

Introduction

The design of the study reported in experiment 3a does not permit analysis of acute effects of specific training sessions on saliva flow and S-IgA, but rather gives a global picture of S-IgA in boxers across a season. Interval training has been shown to affect S-IgA secretion in elite kayakers (Mackinnon et al., 1993a) and collegiate swimmers (Tharp & Barnes, 1990), and boxing training of this nature has been linked to the incidence of infection (Kelvin Travis, ABA Staff Coach, personal communication, 1994). Hence, the aim of this study was to undertake a closer inspection of the acute and cumulative effects of repeated interval boxing training on saliva flow and S-IgA.

It was hypothesised that there would be significant decreases in saliva flow during interval sessions as a consequence of increased symphathetic arousal during exercise, and that this would in turn reduce S-IgA secretion rate following individual sessions. Previous research has reported equivocal findings on the cumulative effects of interval training on S-IgA (MacKinnon et al., 1993b; MacKinnon & Hooper, 1994), hence it was unclear whether a programme of three interval sessions over a seven day period would lead to cumulative decreases.

Method

Participants

The participants were eight amateur boxers aged (mean±SD) 23±2.6 years, who were members of the Royal Navy Boxing Squad based at H.M.S. Nelson in Portsmouth, Hampshire. The S-IgA response to interval training was assessed before and after three regular interval training sessions spaced over a one week period, which formed part of the boxers normal training programme. The Royal Navy coach and all boxers were informed of the nature of the study and gave written consent to participate. One subject did not complete all interval sessions due to injury and was therefore excluded from the study.

Protocol

Participants were weighed prior to each training session. All training sessions took place between 3 and 4 p.m. and were of approximately 30 minutes duration. Training sessions differed from each other to some extent, and since the study focused on boxers undergoing normal training, no attempt was made to alter the training as set by the coach. The three sessions were as follows:

1. Interval session 1 (Tuesday) consisted of working on four boxing specific exercises; the heavy bag, shadow boxing, skipping and the maize bag. High intensity efforts on each exercise lasted 90, 60 and 45 seconds and were interspersed by 20 second rest periods. A two minute rest interval separated work on each exercise. Two circuits of the four exercises were completed.

2. Interval session 2 (Thursday) again consisted of working on four boxing specific exercises; the heavy bag, shadow boxing, the wall pad and coach padwork. High intensity efforts on each exercise lasted 60, 45 and 30 seconds and were interspersed by 20 second rest periods. A two minute rest interval separated work on each exercise, and three circuits of the four exercises were completed.

3. Interval session 3 (Monday) consisted of working on three boxing specific exercises; the heavy bag, shadow boxing and coach padwork. High intensity efforts on each exercise lasted 60, 45 and 30 seconds and were interspersed by 20 second rest periods. A two minute rest interval separated work on each exercise, and three circuits of the three exercises were completed.

Saliva Collections and Saliva Analysis

The procedures used were the same as those described in experiment 3a. Collections took place immediately before and after each interval session.

All of the samples were again assayed in duplicate using ELISA, and regression analysis using the relationship of standard IgA concentrations and amount of absorbance was used to interpolate the S-IgA concentration (μg.ml.$^{-1}$) in the samples. The standard curve of concentration on absorbance resulted in a coefficient of determination of $r^2 = .92$. Test-retest reliability data for the 42 duplicate samples indicated that there was no significant difference ($p>0.05$) between the means.

The same data expression was used as that seen in experiment 3a. However, saliva flow rate was was expressed in μl.min^{-1} rather than ml.min^{-1} due to the small volumes collected.

Results

S-IgA concentrations, S-IgA secretion rates and saliva flow rates were calculated for before (pre) and after (post) each of the three interval sessions. Means and standard errors can be seen in table 6.1.

Table 6.1.
S-IgA Concentrations, S-IgA Secretion rates and Saliva Flow rates (mean ± SEM) Pre and Post Interval Sessions.

	SESSION 1		SESSION 2		SESSION 3	
	PRE	POST	PRE	POST	PRE	POST
S-IgA Conc. (μg.ml^{-1})	577 (88)	608 (51)	596 (43)	569 (16)	551 (48)	622 (25)
Saliva flow (μl.min^{-1})	361 (72)	171 (89)	263 (120)	117 (80)	201 (49)	113 (101)
S-IgA Secr. (μg/min^{-1})	228 (79)	120 (38)	178 (62)	62 (10)	121 (33)	72 (19)

Mean percentage changes over individual sessions were 45-57% for saliva flow, and 41-65% for S-IgA secretion rate. S-IgA concentrations decreased 5% in session 2, but increased 6% and 12% in sessions 1 and 3 respectively.

A Doubly Multivariate MANOVA showed a main effect for pre/post, $\lambda=0.03$ ($F_{3,4}=39.67$, $p<0.005$). Examination of the separate univariate Repeated Measures ANOVA showed that only saliva flow ($F_{1,6}=21.89$, $p<0.005$) and S-IgA secretion rate ($F_{1,6}=10.13$, $p<0.01$) contributed significantly to the results. No significant main effect was found for session, or any significant pre/post X session interactions ($p>0.05$). Additionally, a significant positive correlation ($r=.29$, $p<0.05$) was found between saliva flow and S-IgA concentrations.

The changes in saliva flow and S-IgA secretion rates over the three interval sessions can be seen in figures 6.1 and 6.2.

Figure 6.1.

Saliva Flow Rate Across Interval Sessions

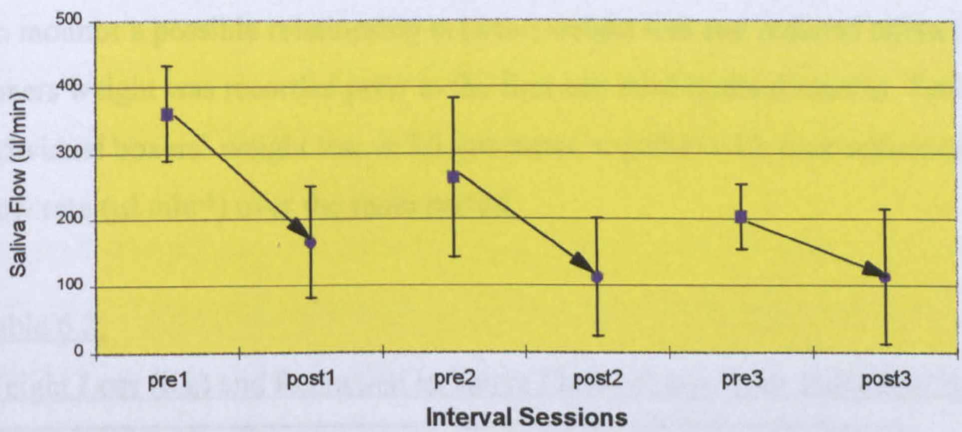
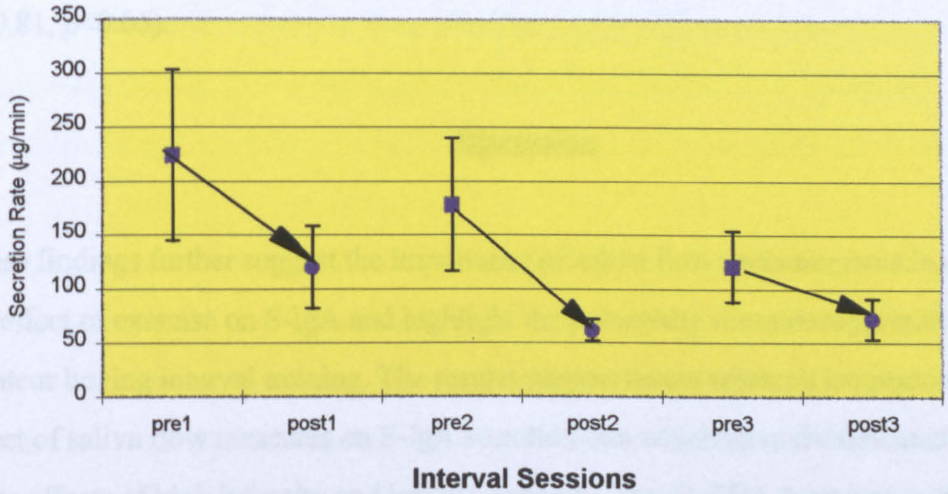


Figure 6.2.

S-IgA Secretion Rate Across Interval Sessions



Weight Loss and Saliva Flow

To monitor a possible relationship between weight loss and reduced saliva flow, each boxers weight was recorded prior to the first and third interval session. Table 6.2 shows individual boxers' weight loss in kilogrammes, together with their reduction in saliva flow rate ($\mu l.min^{-1}$) over the same period.

Table 6.2.

Weight Loss (Kg) and Reduction in Saliva Flow ($\mu l.min^{-1}$) for Individual Boxers

Boxer	Weight Loss (Kg)	Reduction in Saliva Flow ($\mu l.min^{-1}$)
1	2.5	350
2	2.1	238
3	0.5	100
4	0.4	156*
5	1.3	337
6	0.7	38
7	1.5	187
Mean	1.3	156.3

*denotes increase rather than decrease in saliva flow

To analyse the relationship between saliva flow and weight reduction, the total reduction in saliva flow rate was correlated with the total reduction in body weight from pre interval session one to pre interval session three. This showed a significant positive relationship ($r=0.81$, $p<0.05$).

Discussion

These findings further suggest the importance of saliva flow measurements in determining the effect of exercise on S-IgA and highlight the potentially immunosuppressive nature of amateur boxing interval training. The results support recent research incorporating the effect of saliva flow measures on S-IgA secretion rate which have documented negative acute effects of high intensity and interval exercise. The 41-65% decreases in S-IgA secretion rate seen following individual sessions in this study exceeds the 27-38% decreases noted by MacKinnon et al. (1993b) in elite kayakers undergoing interval training and the 17-40% decreases cited following intensive running sessions by MacKinnon and Hooper (1994), but parallels with the 50-60% decreases documented following supramaximal cycling bouts (MacKinnon & Jenkins, 1993).

The finding of no cumulative effect of interval boxing training on S-IgA levels lies in contrast with the longitudinal findings with kayakers (Mackinnon et al., 1993b) where three interval sessions over a three week period resulted in significant decreases in S-IgA concentrations. However, it must be recognised that a trend was emerging over time in this study, indicating further decreases in saliva flow and S-IgA secretion rate for some boxers before sessions began. A similar non-significant trend in S-IgA secretion rate was also observed by MacKinnon and Hooper (1994) following three days of run training. Suitably, the small sample size used in this study (n=7) may have contributed to the finding of no effect for any of the dependent variables across sessions. Likewise, some boxers experienced difficulty in providing a saliva sample, and subsequently the collection of several minuscule saliva samples may point to a floor effect in saliva flow measures in those subjects. Therefore, this factor may also have contributed to the finding of no cumulative effect of interval training on S-IgA secretion rate over the one week period.

The saliva flow rates seen in this study are again substantially below the 1-2 ml. min^{-1} resting values documented by Rudney (1990) and McDowell et al. (1993), and those reported in morning samples in rested, untrained subjects in experiment 3b. Moreover, the flow rates at the start of the first interval session appear lower than the flow rates reported in expriment 3a, and further reductions in saliva flow (45-57%) led to significant decreases in S-IgA secretion rate (41-65%) following individual interval training sessions.

It was suggested in experiment 3a that the unusually low saliva flow rates recorded may have been linked to the weight-making process undertaken by the majority of boxers. This suggestion is supported in this study where all the boxers were preparing for forthcoming competition, and weight loss over the seven day period was significantly related to reductions in saliva flow. Some boxers were deliberately minimising fluid intake during the duration of the study as part of their weight-making strategy, and this self-induced dehydration may explain why there were further non-significant decreases in pre-training saliva flow rates. Dehydration has been associated with increased sympathetic arousal (Wilmore & Costill, 1994) and sympathetic arousal reduces the blood flow to the saliva glands, which reduces saliva flow (Provenza & Siebel, 1986). Furthermore, Pilardeau et al. (1990) have reported that salivary volume is reduced during exercise as a result of increased sympathetic output which limits the water content in saliva, and hence the problem of unusually low resting saliva flow levels in boxers appears to be further exacerbated following interval training

Whilst it is clear that the response of S-IgA secretion rate to exercise can be negatively affected by interval exercise, the principal factor leading to such suppression in boxers appears to be the reduction in saliva flow. Furthermore, the proposed effects of low saliva flow on the innate immune system seem to be heightened through further reductions following interval training. The finding of reduced saliva flow within training sessions may support the proposition by Shephard et al. (1991) and Peters (1997) who argued that during and following exercise there is a drying of the airways which could theoretically lead to an increased risk of URTI. Shephard et al. (1991) proposed that increased ventilation in exercise would increase the rate of evaporation of mucosal fluids and increase their viscosity, decrease ciliary actions and thus provide less protection against invading pathogens.

The minimal flow of saliva also has a negative effect on the acquired immune defence through its influence on S-IgA secretion rates. The secretion rate of IgA is a function of both saliva flow and IgA concentration, hence reduced flow will necessarily affect the amount of S-IgA appearing on the mucosal surfaces. Nevertheless, while this study suggests that the secretion of IgA is affected by interval exercise in boxers, the results do not clarify if the production of S-IgA is also suppressed. To demonstrate such effects on IgA production, changes in S-IgA secretion rate would be needed without any change in saliva flow.

This study further highlighted a problem with using absolute concentrations of S-IgA as a measure of immune function, with no acute or cumulative effects documented. MacKinnon and associates (MacKinnon et al., 1993 a,b; Mackinnon & Jenkins, 1993; MacKinnon & Hooper, 1994) have discussed the limitations of using absolute concentrations of S-IgA, demonstrating inconsistent results when the confounding influence of saliva flow is introduced (MacKinnon & Jenkins, 1993). Stone et al. (1987) have documented two to four fold decreases in S-IgA concentrations with increases in saliva flow, and Evans et al. (1993) found an inverse relationship between the volume of saliva produced and S-IgA concentrations. An inverse relationship, though non-significant, was also found in experiment 3a. Nevertheless, the significant positive correlation found between saliva flow and S-IgA concentration in this study ($r=.29$) denies the existence of an inverse relationship and may explain why S-IgA concentrations did not change in response to the interval training.

It is possible that the potential floor effect witnessed in saliva flow in some boxers which may have contributed to non-significant findings over the three sessions, may also have obscured the true relationship between saliva flow and S-IgA concentrations. This factor, together with the unusually low resting saliva flow levels seen in boxers may result in a different relationship between saliva flow and S-IgA concentrations which has been witnessed in other research (Evans et al., 1993; Kugler, 1991), and could explain why concentrations remained stable over the study. However, it is clear that substantially reduced levels of saliva lining the mucosal surfaces points to impaired innate defences, and the fact that S-IgA concentrations remain unchanged may be of small benefit in the overall protection against URTI, particularly when it is evident that S-IgA secretion rates are also reduced.

It is clear that past research which has incorporated saliva flow measurements have invariably focused on its effects on S-IgA concentrations and secretion rates, whilst the possible effects of decreases in saliva flow following exercise on the innate immune system protection against URTI appear to have been overlooked. Previous researchers monitoring saliva flow have not actually reported the measurements found, nor have they cited evidence of low saliva flow rates in their subjects (e.g. MacKinnon et al., 1993 a, b). More precisely, past studies appear to have investigated sports which are not of a weight classified nature, and hence it may be that saliva flow rates may not have been at a sufficiently low level to have prompted the authors to voice concerns over any impaired innate protection against URTI. Suitably, it may be that boxers and possibly other athletes in weight-classified sports could face an increased risk of URTI, which exceeds the risk faced by other sporting populations, through impaired acquired and innate immune defences.

The observed effects on saliva flow and S-IgA secretion rates are two mechanisms by which participation in boxing training could negatively affect immune function and thus lead to increased risk of URTI, and may provide scientific support for the anecdotal accounts of increased infections seen in boxers during heavy training loads and intense interval exercise. Nevertheless, the implications of this study would seem to extend beyond those involved in boxing training to all athletes participating in weight-classified sports. The importance of salivary flow as an innate immune defence, and its effects on S-IgA secretions may suggest that athletes who train in a semi or dehydrated state, could be increasing the risk of URTI, perhaps due to the need to restrict food and fluid intake in order to make their competition weight category. Suitably, it would appear that the hydration status of the individual boxer may be the major factor limiting efficient initial protection against URTI.

However, practical strategies to combat the potential for infection in boxers would seem difficult to identify, except for any steps taken to minimise the potential for transmission of infections through the environment during boxing training. More importantly, combating dehydration and unusually low saliva volumes through rehydration strategies may not be an option for most boxers if they are struggling to compete at a certain weight class and fluid restriction is needed to promote a reduction in body weight.

Nevertheless, regular massage as an intervention to increase saliva flow may be a possibility. Brenner et al. (1994) have suggested the use of massage by athletes to reduce stress and the risk of infections, and positive effects on saliva flow have been documented in health research on massage by Green and Green (1987). Whilst it is clear that the subjects in this study were not suffering from unusually low resting levels, it is possible that massage could have a similar positive effect on saliva flow in boxers. This is investigated in experiment 5, together with massage effects on mood state following training.

Chapter 7

Experiment 5:

The Effects of Massage on Psychological Regeneration and Saliva Flow Following Amateur Boxing Training

Introduction

At this point in the research project it was felt that the mood state and S-IgA responses of amateur boxers during training had been established. The immediate research question became how to address the negative effects identified in earlier experiments. A review of the relevant literature showed an absence of research assessing the benefits of recovery strategies used following sports training.

Nevertheless, the need to maintain psychological well-being during training phases has been identified in sports literature (Budgett, 1994; Spargo & Horsley, 1994). Murphy et al. (1990) have argued that it is necessary for applied sport psychologists to educate coaches and performers about intervention strategies which will place greater emphasis on sufficient rest and regeneration from increasing training volumes and intensities. A variety of methods to improve emotional recovery during training have been suggested by Spargo and Horsley (1994), including hydrotherapy, saunas, flotation tanks and massage. These authors have argued that regeneration with these strategies can be three times greater than the regeneration gained through passive rest in the post training period. However, Spargo and Horsley (1994) do not provide data to support such claims, and there is a dearth of literature in sports science which provides evidence of controlled investigations into improved psychological well-being after use of these strategies (Budgett, 1990).

Fox (1986) provided some promising evidence suggesting that a variety of regeneration strategies could have positive effects on mood. One of the modalities used by the athletes in the Fox (1986) study was massage, and this modality has been highlighted as having the potential to enhance psychological regeneration during intense training (Shephard & Shek, 1993). Though not in the post training period, promising results using massage have been published by Weinberg et al. (1988), who have shown that massage led to more positive mood in physical education students. The use of massage by athletes appears to be on the increase, with Callaghan (1993) reporting the growing use of massage at an Olympic level for a variety of purposes, which included recovery from exercise.

Whilst Fox (1986) did not specifically focus on the massage/mood relationship and the response to heavy training, the changes in mood state profiles with the use of regenerative techniques may indicate that a more controlled scientific investigation into the acute effects of massage on the mood response and feelings of perceived recovery during training would be beneficial. More pertinently, if massage could be seen to produce immediate post training regenerative effects, then it may be possible to infer that regular massage could offer a method of reducing the mood disturbances seen in boxers in the earlier experiments.

Whilst Weinberg et al. (1988) have demonstrated the psychological benefits of massage in the physical education setting, the design of their study could still be fundamentally flawed. Most importantly, it could be that contact with the masseur alone and the anticipation of massage and its purported psychological benefits could have produced acute positive mood enhancement regardless of the treatment received. While this is acceptable if the goal is purely positive mood enhancement, it does not enable direct scientific support for the massage treatment itself being solely responsible for any positive mood effect. To control for such a limitation another condition is required where contact with the masseur takes place but the ensuing treatment is designed in such a way that no positive effect should result from the treatment.

Earlier experiments documenting the S-IgA response to training in boxers also indicate that saliva flow rates may be the principal factor which needs to be addressed if this potential weakness in initial protection against URTI is to be avoided. Whilst it has been suggested that the unusually low flow rates in boxers may be linked to the weight-classified nature of the sport, there is some evidence that massage could also positively influence saliva flow.

Massage has been shown to promote beneficial effects on immune function in health research (Green & Green, 1987; Green et al., 1988; Groer et al., 1994). The underlying rationale in these studies was that if stress through psychosocial variables could result in immunosuppression, then a relaxation response should result in immunoenhancement, through increased levels of S-IgA.

Green and Green (1987) assigned fifty volunteer college students to one of five twenty minute relaxation experimental conditions: Benson's relaxation response, visualisation, massage, lying quietly and a touching-control group. Saliva samples were collected pre and post intervention. The results showed a significant increase in S-IgA concentrations following Benson's relaxation response, visualisation, massage. More specifically, massage was seen to promote the largest increase in S-IgA concentration. Whilst it has been highlighted earlier in this thesis that saliva flow rate effects on S-IgA concentration have largely not been considered in previous research, Green and Green (1987) showed that their results were not influenced by the saliva flow in their subjects. Flow rates were seen to increase visibly after the relaxation conditions, hence S-IgA concentrations increased despite the possible dilution effect of increased salivary flow. These findings supported the work by Carlson (1986), who found that salivary flow rates increased following relaxation strategies possibly due to the parasympathetic activation which may accompany relaxation. Green and Green (1987) concluded that S-IgA, as one component of the acquired immune system, may be enhanced by the use of various relaxation skills.

The positive results of these studies concerning massage also has implications for the use of massage in the sports setting. Brenner et al. (1994) have suggested that treatment modalities such as massage may reduce psychological and physical stress in athletes and hence reduce the risk of infection. Here, it could be argued that massage used in the recovery process could act to reverse any acute S-IgA suppression experienced as a result of training. More importantly for boxers, massage may enhance the innate immune response, through an increase in saliva flow rates possibly through increased parasympathetic activation (Carlson, 1986).

Thus, this study examined the effect of massage on mood state and saliva flow following amateur boxing training. Furthermore, a touching control condition (Green & Green, 1987) was implemented to negate the sensitisation effects which may limit massage research (Zelikovski et al., 1993). The results of the research by Weinberg et al. (1988) suggested that massage would positively affect the mood states of fatigue, anger, depression and tension. It was unclear whether massage would lead to increases in perceived vigor, as Weinberg et al. (1988) found no changes in this subscale following massage. With respect to possible effects of massage on saliva flow, it was hypothesised that differences would be found between massage and control conditions in the post training phase.

Method

Participants

Nine Royal Navy Boxing Squad members, aged (mean±SD) 22±3.1 years agreed to participate in the study. The Royal Navy coach was briefed on the nature of the investigation.

Instrumentation

The questionnaire used was the boxing modified, shortened version of the POMS described in chapter 3a. However, in this study the instructional set "how you are feeling right now" was used. In addition, boxers were also requested to give responses to four items on a 0 (not at all) to 7 (very much so) linear rating scale designed to explore perceptions of recovery. Numbers 1 to 6 on this scale were undefined and were used to delineate degrees of perceived recovery between the two ends of the scale. The items were *refreshed, recharged, rested* and *recovered.* The proposed items were reviewed and accepted by a panel of three Accredited British Association of Sport and Exercise Sciences (BASES) Sport Psychologists. Morgan et al. (1988) used a similar rating scale in tandem with the POMS to assess perceptions of sluggishness and heaviness in athletes undergoing intensive training programmes. Steptoe and Cox (1988) also added items to the POMS in an attempt to tap into exhilaration type affect following exercise. A copy of the modified POMS with the perceived recovery scale can be seen in appendix 1.

Protocol

Training sessions began at 2 p.m. and lasted 60-75 minutes. Immediately following training sessions, boxers underwent one of three twenty minute interventions. The training sessions formed part of the boxers' normal training programme and the study coincided with a period of intensified training. The sessions were structured by the coach and included a combination of bagwork, skipping, coach pads, circuits and drills and were designed to be of a similar intensity. The interventions were massage, lying resting and touching control. The boxers were informed that the aim of the study was to compare two forms of massage and a passive rest period following training.

Massage

Massage was applied by a qualified sports massage therapist (London School of Sports Massage) and consisted of a standard twenty minute routine encompassing the major muscle groups of the legs (8 min.), back (2 min.), shoulders and arms (10 min.). Whilst the available literature about the duration of massage sets no established time, the twenty minute routine was chosen to replicate recent studies on massage and exercise recovery (Bale & James, 1991; Dolgener & Morien, 1993; Viitasalo et al., 1995; Zelikovski et al., 1993). A stopwatch was worn by the therapist to ensure standardisation of time. The order in which the massage techniques were administered to body parts was consistent throughout treatments. The selected routine was designed to target the main muscles used in boxing performance (Fenn, 1996; Hickey, 1980).

Effleurage (30 strokes per min.) and petrissage (50-60 strokes per min) massage techniques were used. Effleurage massage consisted of rhythmic pressure strokes along the longitudinal axis of each muscle group in a distal to proximal fashion. Petrissage consisted of kneading and squeezing motions over the muscle mass. Participants received treatment lying in the prone position followed by lying supine. The pressure applied followed the recommendations for sports recovery massage cited by Cash (1996). Massage oil (London School of Sports Massage) was used for lubrication on all boxers.

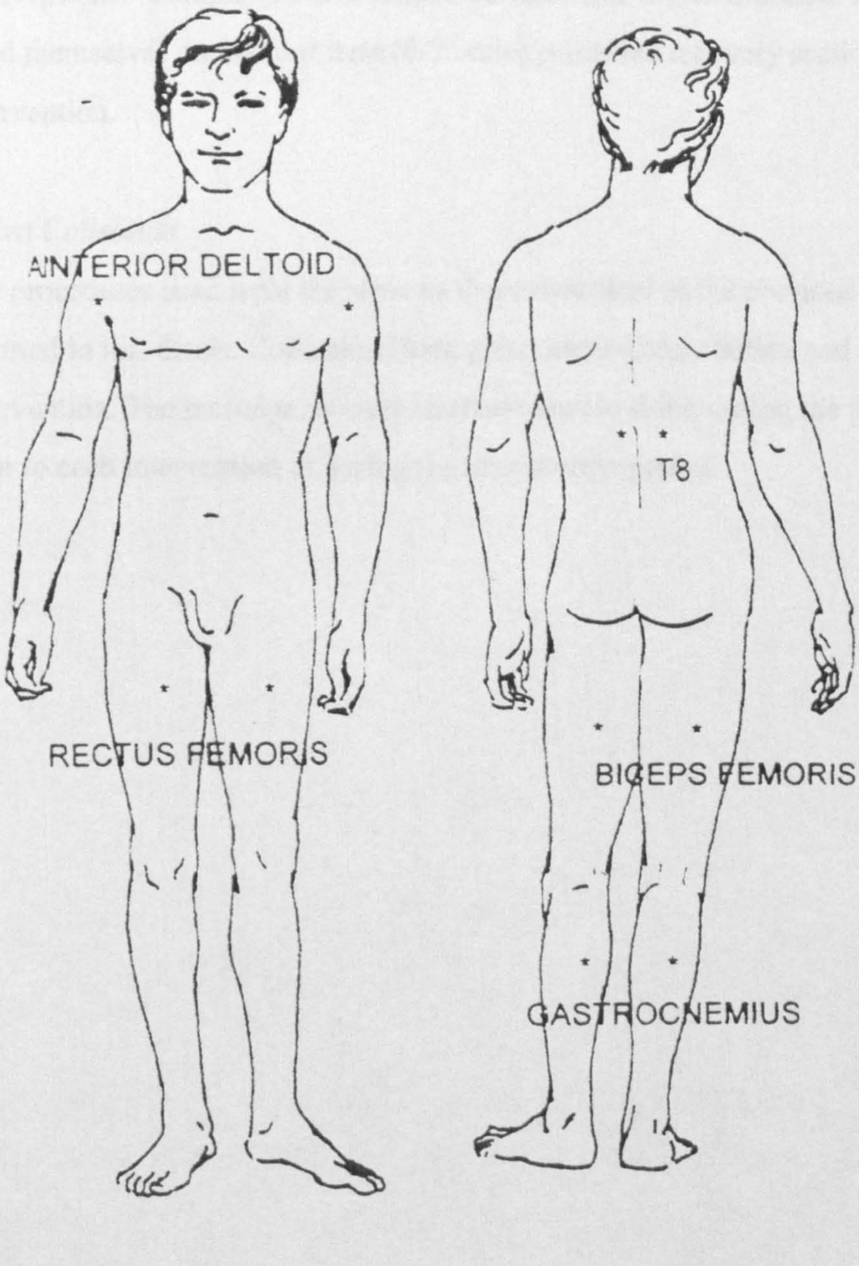
Touching Control

The touching control intervention consisted of contact with the same masseur, however treatment involved the application of finger pressure to a series of pseudo pressure points around the body (see figure 7.1 for body diagram and target sites). A similar touching control condition was successfully employed by Green and Green (1987).

Finger pressure was applied to each of the ten pseudo pressure points for two minutes in a sequential routine, with boxers again assuming the prone followed by supine position. Towels and cushions were used for limb support and coverage in both the massage and touching control interventions. Treatment in both interventions was performed on a portable treatment couch (MarchCouch, UK).

Figure 7.1.

Body showing Pseudo Pressure Points in Touching Control Intervention



Lying Resting

When undertaking this intervention boxers were asked to lie resting quietly on comfortable mats, again for a period of twenty minutes. They were requested not to sleep and listening to music was not permitted.

The period of time between interventions for each boxer was a maximum of three days, with interventions completed in a counter-balanced design. Boxers were not informed of which intervention they would be receiving prior to the training session.

Mood States and Perceived Recovery

Boxers completed the modified POMS immediately before and after each of the interventions. Completion time ranged between one to two minutes. The boxers also rated themselves on the four item (0-7 scale) perceived recovery section after each intervention.

Saliva Collection

The procedures used were the same as those described in the previous experiments reported in this thesis. Collections took place immediately before and after each intervention. The participants were instructed not to drink during the training session prior to each intervention or during the intervention period.

Results

Mood State and Perceived Recovery

Means and standard deviations for mood states and perceived recovery before (pre) and after (post) each intervention can be seen in tables 7.1 and 7.2.

Table 7.1.

Mood State Mean (±SD) in Lying Resting, Touching Control and Massage Interventions

Mood & Scale Range	Lying Resting		Touching Control		Massage	
	Pre	Post	Pre	Post	Pre	Post
Anger (0-16)	1.56 (2.65)	1.22 (2.33)	1.89 (2.76)	1.22 (2.33)	2.67 (3.81)	1.89 (3.95)
Depression (0-16)	2.00 (2.83)	2.00 (2.83)	1.56 (2.83)	1.33 (2.4)	2.44 (2.79)	2.00 (2.69)
Fatigue (0-16)	8.67 (3.64)	7.89 (4.11)	9.33 (3.46)	7.89 (3.22)	8.44 (3.36)	4.33 (1.94)
Vigor (0-16)	5.22 (2.99)	4.00 (2.00)	5.56 (3.17)	4.44 (2.24)	5.11 (3.82)	4.89 (3.26)
Tension (0-20)	4.78 (3.9)	4.22 (3.99)	5.22 (3.56)	4.11 (3.22)	4.67 (3.24)	2.67 (2.12)

Table 7.2.

Mean (±SD) for Perceived Recovery Post Interventions (0-28 range)

Lying Resting	Touching Control	Massage
9.33 (4.00)	6.67 (3.08)	16.56 (4.85)

Mood state subscales were analysed via a series of 3 (intervention) X 2 (pre/post) Repeated Measures ANOVA, with both independent variables as repeated measures factors, and revealed a significant interaction for the fatigue subscale ($F_{2,16} = 5.25$, $p<0.05$). Post hoc Tukey tests showed Massage Post < Massage Pre, and Massage Post

< Lying Resting/Touching Control Post. This interaction superseded the main effects found in the fatigue subscale (Massage < Touching Control/Lying Resting, $F_{2,16} = 6.00$, $p<0.05$; Post < Pre, $F_{1,8} = 20.34$, $p<0.005$). A main effect was also found for the tension subscale (Post < Pre , $F_{1,8} = 7.93$, $p<0.05$). No main effects or interactions were found on the mood subscales of vigor, depression and anger. Analysis of the additional perceived recovery section with a one-way ANOVA, with intervention as the repeated measure, showed a significant difference (Massage > Lying Resting/Touching Control, $F_{2,16} = 28.82$, $p<0.001$). No difference in perceived recovery was found between Touching Control and Lying Resting interventions.

Correlational analysis showed perceptions of recovery were significantly related to reductions in perceptions of fatigue ($r = .71$, $p<0.05$).

The changes in perceptions of fatigue and perceived recovery are presented in graphical form in figures 7.2 and 7.3.

Figure 7.2.

Fatigue mood state scores pre and post massage, lying resting and touching control interventions

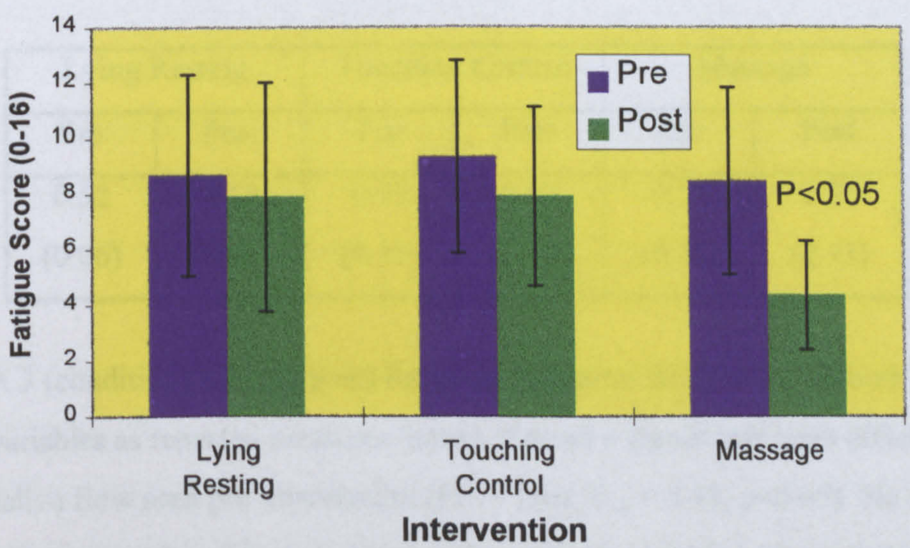
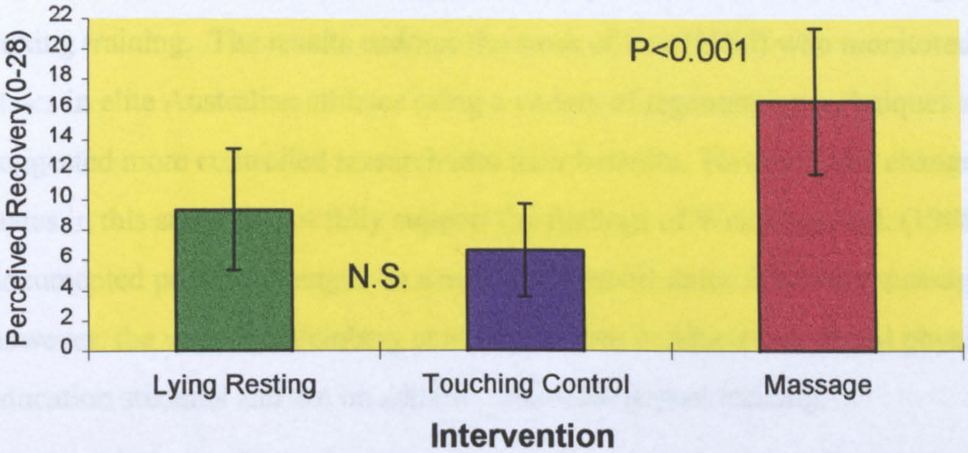


Figure 7.3.

Perceived recovery following massage, lying resting and touching control interventions



Saliva Flow

Saliva flow means and standard errors before (pre) and after (post) each intervention can be seen in table 7.3.

Table 7.3.

Saliva Flow ($ml.min^{-1}$) means (±SEM) in Lying Resting, Touching Control and Massage Interventions

Lying Resting		Touching Control		Massage	
Pre	Post	Pre	Post	Pre	Post
0.52 (0.06)	0.58 (0.08)	0.55 (0.11)	0.57 (0.09)	0.53 (0.11)	0.55 (0.13)

A 3 (condition) x 2 (pre/post) Repeated Measures ANOVA, with both independent variables as repeated measures factors showed a significant main effect, with lower saliva flow seen pre intervention (Pre < Post, $F_{1,8} = 3.42$, $p<0.05$). No significant main effects were found for intervention ($F_{2,16} = 0.09$, $p>0.05$) or the intervention X pre/post interaction ($F_{2,16} = 0.42$, $p>0.05$).

Discussion

These findings indicate that massage can positively affect acute psychological regeneration, in the form of perceptions of fatigue and recovery, following amateur boxing training. The results endorse the work of Fox (1986) who monitored mood states in elite Australian athletes using a variety of regenerative techniques and suggested more controlled research into their benefits. However, the changes in mood states in this study do not fully support the findings of Weinberg et al. (1988) who documented positive changes in a number of mood states following massage. Notably, however, the work by Weinberg et al. (1988) was conducted on rested physical education students and not on athletes immediately post training.

This research also addresses some of the limitations inherent in the study conducted by Weinberg et al. (1988). It was previously suggested that the psychological benefits of massage witnessed by Weinberg et al. (1988) could have been influenced by the anticipation of massage and its purported psychological benefits rather than through the massage treatment itself. The touching control condition included in this research design was employed to eradicate this problem, and enables greater support for the massage treatment being responsible for the positive effect on perceptions of fatigue and recovery. Few explanations have been suggested with regard to potential pathways for massage to enhance positive affect. Kaada and Torsteinbo (1989) found a 16% increase in plasma endorphin concentration after massage and suggested that the release of endorphins may be the mediator in the sensation of well-being following massage. Additionally, Longworth (1982) proposed that massage could promote a feeling of well-being through decreased arousal levels.

The finding of no effect of massage on the subscales of tension, vigor, anger and depression following training is also important as earlier experiments in this thesis have shown changes in these mood states during periods of intensified training. Vigor, in particular has displayed the large fluctuations similar to those seen in earlier studies (e.g. Morgan et al., 1987) and it appears training induced changes in this somatically based mood (Raglin, 1993) may not be counteracted by massage. The original POMS vigor scale (McNair, et al., 1971) was constructed to measure a mood of vigorousness, ebullience and high energy, and it is worth noting that Weinberg et al. (1988) found the vigor subscale to be the only mood state unaffected by massage, citing a possible ceiling effect in the sample used. The vigor scores in this study prior to each intervention did not indicate any ceiling effects, and post intervention group means actually showed non-significant decreases. Hence, it appears massage does not affect perceptions of vigor.

Nevertheless, it is possible that floor rather than ceiling effects may have led to non-significant findings in some of the remaining mood states in the present study. For instance, the mean scores for depression, tension and anger were lower than those seen in experiment 3a which documented mood state changes with the new shortened, boxing specific inventory. Some individual boxers had zero scores on these mood states prior to interventions, and hence it is not possible to examine for any effects of massage or any intervention when a floor effect in subjective ratings exists.

Indeed, it is acknowledged that this limitation may have prevented the finding of significant changes in the mood state tension following massage. The probability level was approaching significance at 9%, and with low statistical power (0.49), there may be the possibility of a type II error. It is evident that tension scores were moving sufficiently in the right direction to suggest that significance may have been achieved if the sample size (n=9) had been greater. Franks and Huck (1986) have argued that the probability level could be raised to 10% in exploratory studies of this nature or when there are limitations in sample size which occur frequently in physical education research. Furthermore, Weinberg et al. (1988) found large changes in the tension subscale following massage, hence further research may be needed to clarify this mood response to massage in the post training phase.

The finding of lower mean scores in tension, anger and depression in this study compared with experiment 3a are not readily explainable. It has been argued that tension related affect is also linked to cognitive concerns about forthcoming competition during training (Raglin, 1993), and it may be that the competition the boxers were preparing for during this study was perceived to be of lesser importance, which is reflected in the lower scores recorded. It is also possible that the training intensity in this study differed from earlier monitoring, however this seems unlikely as the somatically based fatigue and vigor moods (Raglin, 1993), which are highly susceptible to changes in training load (Morgan et al., 1987), seem to be consistent with the findings of experiment 3a.

The process of monitoring for perceived recovery following each intervention also provided an additional dimension to the study of psychological regeneration following massage. Previous authors have suggested the use of multiple monitoring tools to tap into different aspects of psychological well-being in intensively trained athletes (Hooper & MacKinnon, 1995), whilst Kuipers (1996) emphasised the importance of monitoring both psychological and physiological markers of recovery in the prevention of overtraining. Suitably, the four item section on perceptions of recovery was designed with these comments in mind, and also a similar 0-7 rating scale had been used to measure perceptions of muscle fatigue/soreness and tiredness in athletes (Morgan et al., 1988). The results gained in this study point to powerful effects of massage on perceived recovery and to a strong relationship between perceived recovery and perceived reduction in feelings of fatigue, which in the latter case, one may expect. However, these findings should be taken as preliminary evidence and further research is needed to document these perceptions of recovery.

It should also be recognised that the instructional set which accompanies the shortened POMS was changed in this study from how you are feeling "last week including today" to "right now". Whilst discussing more specifically the mood-performance relationship, Terry (1995) has suggested that the transient nature of moods can often lead to problems when using the longer time reference and remarked that many researchers fail to report the instructions to participants. The design of this study demanded the use of the shorter time reference, however it should be noted that the new inventory was developed using the longer time reference. McNair et al. (1971) have indicated that changing the POMS instructional set could affect psychometric properties, yet it is also clear that the shortened version provided a better tool for monitoring the rapid psychological changes of interest. Grove and Prapavessis (1992) have previously alluded to this strength of a shortened POMS version, and it seems feasible to suggest that the possible disadvantages of a changed instructional set are outweighed by the advantages of the shortened POMS alternative in this instance.

This study also documented the effects of massage on post training saliva flow rates in boxers. The finding that massage did not lead to increased saliva flow does not support the work of Green and Green (1987). These authors found increases in saliva volume in their subjects and proposed that they were due to increased parasympathetic activation which could accompany massage and other forms of relaxation, a suggestion also forwarded by Carlson (1986).

Nevertheless, it must be recognised that the participants in the Green and Green (1987) study were not athletes in training, and more importantly were probably adequately hydrated throughout the research design, although actual flow rates were not quoted. In contrast, the boxers in this study had unusually low saliva flow rates, with means before interventions ranging between 0.51-0.55 $ml.min.^{-1}$, mirroring the previous experiments in this thesis documenting the S-IgA response in boxing. Suitably, whilst there was a main effect suggesting an increase in flow rates after all interventions, the fact that sympathetic inhibition of saliva flow was probable during the boxers' training (Pilardeau et al., 1990; Wilmore & Costill, 1994), coupled with the potential for varying degrees of dehydration in boxers linked to the weight-classified nature of the sport, may explain the finding of no effect of massage on this measure. Hence, it appears massage is unable to counteract the potential weakness in innate protection against URTI which has been hypothesised to exist in boxers.

To conclude, the results of this study provide preliminary evidence of massage increasing acute psychological regeneration immediately following a boxing training session. This may suggest that regular massage could play a role in reducing perceptions of fatigue and increasing perceptions of recovery in boxers involved in extended, intensified training programmes, although the effects of massage on mood state over an extended period have not been demonstrated. In contrast, massage was not shown to increase saliva flow rates in boxers in the post training period.

The positive finding of massage effects on psychological status may also have implications for boxing performance. Weinberg et al. (1988) discussed the need for greater research into the links between massage, positive affect and performance in sport. The common use of massage in competitions, together with the paucity of well-controlled investigations on the massage-performance relationship also led Cafarelli and Flint (1993) to call for more research in this area. Likewise, it has been established that empirical studies on the physiological benefits of massage are limited, and in many textbooks statements about the possible physiological effects of techniques are primarily speculative. In experiment six, some of these factors are addressed in an interdisciplinary approach to the effects of massage on psychological regeneration, physiological recovery and amateur boxing performance in a laboratory based task.

Chapter 8

Experiment 6:

The Effects of Massage on Psychological Regeneration, Physiological Recovery and Repeated Amateur Boxing Performance

Introduction

The quality of recovery between performances in amateur boxing is often of critical importance. At the international level, in multi-nation tournaments the period between bouts is usually less than twenty-four hours, though rarely less than twelve hours (I. Irwin, National Coach, personal communication, 1995). However, domestic competition is far more time constrained with the possibility of competing twice in a single evening, with as little as a one hour rest period separating contests. These time constraints, particularly the latter scenario, present problems with regard to adequate recovery.

Recovery from fatigue is considered crucial if an individual is to perform any kind of repeated exercise effectively within a short period (Åstrand & Rodahl,1986). There has been a great deal of research which has focused on energy replacement strategies between exercise (Wilmore & Costill, 1994), and Smith (1993) has developed specific energy replacement/rehydration strategies for boxers, though these are principally aimed at the post weigh-in period before competition.

Massage is one method used by athletes post exercise to promote recovery and also as a means of preparing for exercise (Samples, 1987; Ylinen & Cash, 1988). Few studies have systematically evaluated massage as an intervention between bouts of high intensity exercise (Cafarelli & Flint, 1993). Moreover, no studies appear to have simultaneously monitored psychological and physiological components of recovery and subsequent exercise performance.

The potential for massage to influence psychological regeneration, as measured by reduced perceptions of fatigue and increased perceptions of recovery, in the post training phase was demonstrated in experiment five. Additionally, psychological regeneration was suggested to explain improvements in repeated performance, when no physiological benefits were apparent in the recovery phase (Zelikovski et al., 1993). These results would tend to suggest that a similar regenerative effect on mood could be gained through the use of massage in recovery from an initial performance and preparation for subsequent performance in amateur boxing.

Here, it is not proposed that a specific mood profile is required for, or will predict, successful performance. Rather, massage has been shown to influence the mood state fatigue in experiment five, and other mood states in non-athletes (Weinberg et al., 1988). It would seem intuitively appealing to suggest that any negative post performance fluctuations in mood states could be reversed through massage treatment. For instance, feelings of tiredeness, fatigue and reduced power have been documented following simulated boxing performance (Smith, 1997) and it could be argued that repeated boxing performance may improve if perceptions of enhanced recovery could replace feelings of tiredness and fatigue.

Past research on physiological aspects of recovery suggests that active methods can promote more efficient lactate removal than massage following exercise (Gupta et al., 1996). However, at present, studies have not clearly identified if massage is more beneficial than passive rest in removing lactate during recovery (Bale & James, 1991; Dolgener & Morien, 1993; Gupta et al., 1996; Zelikovski et al., 1993). Lactate removal is documented as a key benefit of massage in non-scientific sport literature (Samples, 1987; Ylinen & Cash, 1988), and subsequently it would seem important to investigate this marker of physiological recovery further in massage and passive rest conditions. This may be important as there are potential situations in sport where it may be impractical to perform an active recovery method between performances, such as when there is a space restriction at a competition venue or, as is often the case in boxing, when minor injuries need to be treated. There is also the practical consideration that many athletes may prefer an alternative to an active recovery strategy.

Additionally, the effects of massage on sports performance are still poorly understood despite various anecdotal testimonies to its efficacy. Cafarelli and Flint (1993) have highlighted the fact that the effects of massage on repeated performance is an area particularly under researched. Considering the widespread use of massage in sport for performance enhancement (Samples, 1987), this is rather surprising. The little research completed to date has provided some equivocal findings (Drews et al., 1990; Zelikovski et al., 1993), however it is unclear whether the large increases in repeated running performance seen using a mechanical massage device (Zelikovski et al., 1993) can be replicated in amateur boxing performance using manual massage techniques.

Objective measures of performance have also been questioned in sport science research. For instance, it has been argued that previous sport psychology research focusing on performance effects of various interventions have been hampered by performance classification problems (Renger, 1993). Here, performance has been frequently been operationalised in absolute terms using finishing position, win/loss outcome or time (Rowley et al., 1995). While it has been argued that performance categorised on a relative rather than absolute basis provides more sensitivity (Terry, 1995), performance in many sports remains difficult to quantify. Nevertheless, in pursuit of greater ecological validity, the effects of massage on boxing performance are enabled through the use of sport specific ergometry developed to monitor punching force characteristics in amateur boxing (Smith, Hale & McManus, 1994; Smith, Hobbs, Dyson, Fallowfield & Hale,1996; Smith, Metcalfe, Dyson, Fallowfield, Wilkinson & Hale,1996).

In his doctoral thesis, Smith (1997) documented the finding that over the past twenty years boxing specific research had primarily focused on the construction of ecologically valid systems which provided a quantitative measure of punching force. Mechanical systems based on punch bag dynamometry were developed in Germany in the late 1970's (Joche, Fritsche & Krause,1981), with evidence of similar ergometry being used in Russia (Filimonov, Kopste, Husyanov & Nazarov, 1983). However, Smith (1997) noted the limitations of these previous attempts, specifically the measurement of force in only a single plane, and also the absence of any evidence of calibration or reliability data.

To summarise, the purpose of this study was to examine further the effects of massage on psychological regeneration, however this being in the post performance period. Another aim was to document a physiological component of recovery, blood lactate, in an attempt to provide an interdisciplinary explanation of massage effects on recovery and subsequent punching performance on a boxing ergometer. It was hypothesised that massage would lead to increased psychological regeneration, however it was unclear if massage would lead to greater lactate clearance or improved boxing performance.

Preliminary study

As a further measure to increase safety in amateur boxing, the Amateur International Boxing Association (AIBA) introduced a new bout format from the 1st January 1997. This rule change altered the length of contests from three 3 minute rounds to five 2 minute rounds. The rule change resulted from research by the AIBA Medical Commission which had discovered a large number of knockouts and stoppages were seen in the final minute of the three minute round, when fatigue was likely. Hence, to design a suitable performance protocol for the main study, it was necessary to investigate the performance demands of the new five 2 minute bout duration. It was felt that video analysis to identify punch rates during actual contests would improve the external validity of the main study.

Video analysis of ten amateur boxing bouts (five 2 minute format) was undertaken. The footage covered competition from the 1990 World Cup Multi-Nations and the England verses U.S.A. dual international in 1997. A range of competition weight categories from lightweight (60 kg) to light-heavyweight (81kg) were observed. The total number of punches thrown per round by English boxers were counted. This enabled a total bout punch rate to be identified and hence an average punch rate per round. Compilation of punch data for all ten bouts indicated an average of sixty punches per round.

A simulated audio tape of two minutes duration was then constructed which consisted of sixty straight punches. The punching patterns were in either one (single lead or rear hand), two or three punch combinations. The straight punching protocol was adopted as, within amateur boxing, there seems to be an increased emphasis on this type of punch since the introduction of the computerised scoring machine in the judging of contests. This view seems to be shared amongst current national coaches in Europe (I.Irwin, National Coach, personal communication, 1994).

Introduced at the World Senior Championships in Moscow, 1989, in an attempt to eliminate the biased judging seen at the Seoul Olympics the previous year, the machine requires each of five judges located around the ring to press a red or blue button (corresponding with competitor colours) when the judge is of the impression that the boxer has landed a punch with sufficient force on their opponent's target area. Three out of the five judges must press the same button within one second in order for a point to be registered. The introduction of this machine appears to have produced a new philosophy in competition, altering tactics and most notably the type of punch thrown now appears to be predominantly straight, either singularly or in small combinations. This was borne out in the video analysis, where over 80% of punches thrown were straight.

An amateur boxer then performed the punching protocol in the prescribed sequence on a boxing punchbag (Bryan, UK) responding to the audio cues. The boxer performed five 2 minute rounds interspersed with a one minute seated recovery after each round. Heart rate was continuously monitored by short range telemetry throughout the performance (Polar Sports Tester, Kemple, Finland) and a 50μl fingerprick capillary blood samples were drawn to determine blood lactate concentrations immediately, and five minutes post performance (2300 StatPlus, YSI, Ohio, USA). Peak heart rate following the simulated performance was 160 $b.min^{-1}$, whilst blood lactate values were 4.3mM and 3.9mM immediately post and five minutes post performance respectively. Maximal exercise testing values on this subject had previously been collected.

These values were not considered to be an acceptable and valid reflection of the physiological stress imposed during amateur boxing performance. Previous monitoring of physiological responses during amateur boxing has occurred as part of a sport science support programme, and are documented in detail by Smith (1997). Measurements based on the pre-1997 three 3 minute round format have shown heart rate to be near maximal in a contest, with post bout blood lactate often in excess of 10mM (England v Poland, 1989, range: 9-18mM).

In attempting to simulate amateur boxing performance in the laboratory, Smith (1997) has experienced similar problems in reproducing the physiological stress experienced by boxers in competition. This author has indicated that laboratory protocol involving audio cues and the punching of boxing specific ergometry, may not adequately simulate the necessary footwork and lateral leg and upper body movement that is experienced in an actual contest. Previous studies by Smith (1997) have shown punch rates had to be increased to between 95-110 per round in order to mimic the physiological demands that seem to accompany a competitive bout. Nevertheless, these punch rates were based on the longer three 3 minute round duration which existed domestically up to the end of 1996.

It was therefore decided that a similar process would have to be followed in order to increase the physiological stress imposed on boxers in the main study. Preliminary data collected on international boxers since the inception of the new five 2 minute bout duration had shown blood lactate to range between 5-10mM following a contest. Subsequently, a new audio tape was constructed which included eighty punches per round, with the anticipation that increased physiological demands would be imposed. Another simulation took place using the same boxer with the new punching sequence. Physiological values post bout showed heart rate to be 180 $b.min^{-1}$, whilst blood lactate values were 5.97mM and 5.49mM immediately post and five minutes post performance respectively. These values compared favourably with preliminary data collected analysing the five round format, and it was therefore decided that the eighty punch per round protocol would be acceptable for the main study. The punching sequence can be found in appendix 2.

Main Study

Method

Participants

Eight male amateur boxers (mean±SD) aged 24.9±3.8 years, height 1.8±0.07 metres, volunteered to participate in the study. Written consent forms were obtained, and all participants completed health history questionnaires. The boxers were all members of the Chichester Institute of Higher Education Amateur Boxing Club and had been participants in the sport for a minimum period of two years.

Instrumentation

Psychological Measures

The boxing modified POMS was used. When completing the questionnaire, the participants were asked to respond to the items using the "right now" instructional set. The additional four item recovery section was also included for completion post intervention.

Physiological Measures

During boxing performances heart rate was recorded every fifteen seconds and stored to memory for subsequent analysis. 50μl fingerprick capillary blood samples were drawn to determine blood lactate and glucose concentrations. Blood glucose concentrations were also recorded to monitor if blood lactate concentrations were influenced by the availability of glucose as an energy substrate (Wilmore & Costill, 1994).

Performance Measure

The design, construction and calibration of the boxing ergometer system has been described in detail by Smith (1997). A unique feature of the ergometer is that it permits the identification of a pathway of force production for each type of punch due to its three dimensional sensitivity. Previous results have indicated that the ergometer is a valid and reliable instrument, and is capable of discriminating between elite, intermediate and novice boxers in a range of punches (Smith, 1997). Briefly, three dimensional information is derived from the ergometer measurement system using matched 9366 force sensors (Kistler, Winterthur, Switzerland). This information is passed in analogue form to a 12 bit Amplicon (Brighton, England) analogue to digital converter. The digital information is then processed and displayed using a punch analysis software running within a Provec 5.0 software package (Orthodata Ltd., Ludenscheid, Germany). Data is then sampled at 500 Hz by the software package and stored to the hard disc of a Viglen 486 computer and printed on a Mannesmann 904 printer. The outer physical shape of the ergometer is that of typical wall mounted pad seen in boxing gymnasiums and is made from reconstituted chip foam and leather (MK Sports, Rochdale, UK). The height of the ergometer can be altered, enabling the target area to correspond with the height of the boxer.

In this study, punching force measured in Newtons was recorded. Mean peak force was determined per punch in each round, providing a measure of boxing performance. Due to the punching protocol being that of straight lead and rear hand punches either singularly or in two and three punch combinations, the force data collected in the Fz (anterior-posterior) plane was selected for analysis. The Fx (medio-lateral) and Fy (vertical) planes are considered more applicable to force measurement in hook and uppercut punches (Smith, 1997).

Protocol

All participants were habituated to punching the boxing ergometer in the two week period prior to the commencement of the study.

Each boxer performed two trials in a counter-balanced design, separated by a seven day recovery period. Participants maintained a normal diet throughout the experiment period, and refrained from intensive training. For both trials, the participants entered the laboratory having refrained from physical activity over the previous forty-eight hours. Each boxer's mass (Avery scales, UK; calibrated ±100g) was determined prior to completing performance one, which consisted of a five 2 minute round, interspersed with one minute seated recovery period, simulated boxing bout. This comprised eighty punches per round, performed in a prescribed sequence from an audio cue, as described in the pilot study. Each participant was instructed to produce a maximal effort with every punch, and were reminded of the importance of stepping into and away from the ergometer and of trunk movements between punching sequences. A ten minute self-selected warm-up comprising stretching, jogging and hitting hand held coaching pads (Bryan, UK) was conducted prior to the bout simulation. Crepe hand bandages (2.5m length, 0.05 m width) were worn by each participant underneath competition gloves (284 gms; Top Ten, Germany).

Immediately post performance one, subjects undertook one of two twenty minute interventions. The interventions were massage and no massage. Massage was applied by a qualified therapist and consisted of the same routine outlined in experiment 5. In the no massage intervention, particpants lay resting on mats. Boxers were not aware of the intervention to which they were assigned in their first visit to the laboratory. Following the intervention, subjects had a further thirty-five minute rest period. Fluid (250ml water) was permitted in this rest period and participants were instructed to sit and rest. After this rest period participants completed another self-selected warm-up and a second performance, which was a repeated simulation of performance one. Therefore, there was a one hour period between the two boxing performances; the minimum period for domestic amateur boxing competition. Monetary prizes were offered in both performances in each trial in an attempt to raise the motivation of participants in what was considered to be a physically demanding experimental design.

Immediately prior to and following each intervention the participants completed the boxing POMS. Boxers also rated themselves on perceived recovery following each intervention. Peak heart rate was recorded post round in both performances, and blood lactate and glucose concentrations were drawn immediately before and after performance one, immediately following the intervention, and immediately before and after performance two. The complete experimental design is shown in figure 8.1.

Figure 8.1

Crossover Experimental Design

	TIME
MEASURE BODY MASS	TIME
PRE PERFORMANCE 1 BLOOD LACTATE /GLUCOSE	
WARM UP	10
PERFORMANCE 1 (5 X 2 MIN., 1 min. recovery between rounds)	14
POST PERFORMANCE 1 BLOOD LACTATE/GLUCOSE	
COMPLETE BOXING POMS	2
INTERVENTION: MASSAGE	20
POST INTERVENTION BLOOD LACTATE/GLUCOSE	
COMPLETE BOXING POMS/PERCEIVED RECOVERY	2
REST	35
PRE PERFORMANCE 2 BLOOD LACTATE/GLUCOSE	
WARM UP	10
PERFORMANCE 2 (5 X 2 MIN., 1 min. recovery between rounds)	14
POST PERFORMANCE 2 BLOOD LACTATE/GLUCOSE	

REST PERIOD OF 7 DAYS

MEASURE BODY MASS	TIME
PRE PERFORMANCE 1 BLOOD LACTATE /GLUCOSE	
WARM UP	10
PERFORMANCE 1 (5 X 2 MIN., 1 min. recovery between rounds)	14
POST PERFORMANCE 1 BLOOD LACTATE/GLUCOSE	
COMPLETE BOXING POMS	2
INTERVENTION: NO MASSAGE (Lying Resting)	20
POST INTERVENTION BLOOD LACTATE/GLUCOSE	
COMPLETE BOXING POMS/PERCEIVED RECOVERY	2
REST	35
PRE PERFORMANCE 2 BLOOD LACTATE/GLUCOSE	
WARM UP	10
PERFORMANCE 2 (5 X 2 MIN., 1 min. recovery between rounds)	14
POST PERFORMANCE 2 BLOOD LACTATE/GLUCOSE	

Results

Body Mass

A paired t-test showed no significant differences between interventions for pre performance 1 body mass (massage 78.17 ± 8.16 kg, no massage 78.27 ± 9.11 kg, $t_7 = -0.43$, $p>0.05$).

Punching Force

Punching force means (±SEM) during performances 1 and 2 in massage and no massage interventions can be seen in table 8.1.

Table 8.1

Mean (±SEM) Punching Force (Newtons) for Performance 1 and 2 in Massage and No Massage Interventions

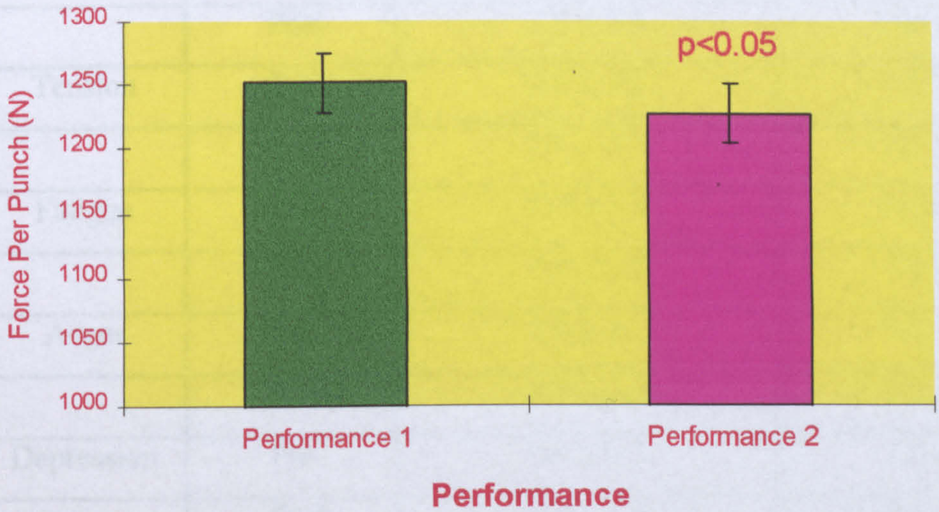
Performance & Round	Massage	No Massage
Performance1 Round 1	1206±69	1220±77
Performance1 Round 2	1283±68	1267±89
Performance1 Round 3	1300±73	1230±90
Performance1 Round 4	1275±71	1226±85
Performance1 Round 5	1263±72	1239±82
Performance2 Round 1	1196±72	1179±86
Performance2 Round 2	1246±68	1209±84
Performance2 Round 3	1239±60	1207±84
Performance2 Round 4	1234±66	1220±89
Performance2 Round 5	1288±68	1254±84

Punching force was analysed with a 2 (intervention) X 2 (performance) X 5 (round) Repeated Measures ANOVA, with all independent variables as repeated measures factors, and revealed significant main effects for performance (Performance 1 > Performance 2, $F_{1,7} = 7.31$, $p<0.05$) and round (Round 1 < Rounds 2-5, $F_{4,28} = 6.38$, $p<0.001$). No significant main effects were found for intervention ($F_{1,7} = 0.31$, $p>0.05$).

Analysis of interaction effects showed that only the performance X round interaction was significant ($F_{4,28} = 4.59$, $p<0.01$). Post hoc Tukey tests showed lower punching force values in performance 2 round 1 compared with performance 1 rounds 2 to 5. Finally, the two and three way interactions involving intervention were all non-significant ($p>0.05$). Figure 8.2 shows the reduction in punching force seen in performance 2.

Figure 8.2.

Difference in punching force between performances 1 and 2 (mean ± SEM)



Mood State and Perceived Recovery

Mood state and perceived recovery means (±SD) pre and post interventions are shown in tables 8.2 and 8.3.

Table 8.2.

Mood State Means (±SD) Pre/Post Intervention for Massage and No Massage Interventions

Mood	Pre/Post	Massage	No Massage
Vigor	Pre	4.9 ± 3.9	4.6 ± 3.7
	Post	7.5 ± 3.2	5.1 ± 4.1
Tension	Pre	4.1 ± 3.2	4.8 ± 3.5
	Post	1.5 ± 2.7	2.9 ± 2.1
Fatigue	Pre	11.1± 3.8	11.2± 4.2
	Post	4.1 ± 2.8	7.3 ± 3.7
Anger	Pre	2.5 ± 4.2	2.4 ± 3.4
	Post	1.0 ± 2.4	1.0 ± 1.2
Depression	Pre	0.4 ± 0.7	1.0 ± 1.9
	Post	0.6 ± 1.4	0.5 ± 1.4

Table 8.3.

Perceived Recovery Means (±SD) Post Intervention in Massage and No Massage Interventions

	Massage	No Massage
Perceived Recovery	19.0 ± 3.8	12.1 ± 4.0

Mood state sub-scales were analysed via a series of 2 (intervention) X 2 (pre/post) Repeated Measures ANOVA, with both independent variables as repeated measures factors, and revealed significant main effects (pre > post) for fatigue and tension, and vigor (post > pre). Significant main effects were also found for intervention (no massage > massage) in fatigue and tension, and vigor (massage > no massage). A significant interaction for the fatigue subscale was also found ($F_{1,7} = 10.50$, $p<0.05$). Post hoc Tukey tests showed lower levels of fatigue post intervention in the massage condition. No interaction effects were found on vigor, tension, anger and depression. Analysis of perceived recovery with a Wilcoxon matched pairs test showed a significant difference between interventions (Massage > No Massage, $Z = -2.38$, $p<0.01$). The significant effects seen on fatigue and perceived recovery are shown graphically in figures 8.3 and 8.4.

Finally, reductions in perceptions of the mood state fatigue were correlated with perceptions of recovery. This showed a significant relationship ($r = .62$, $p<0.005$).

Figure 8.3.

Effects on the fatigue mood state in massage and no massage interventions

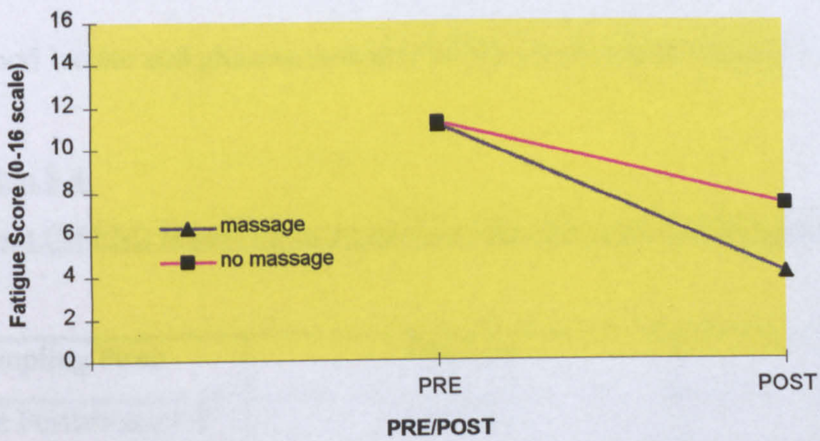
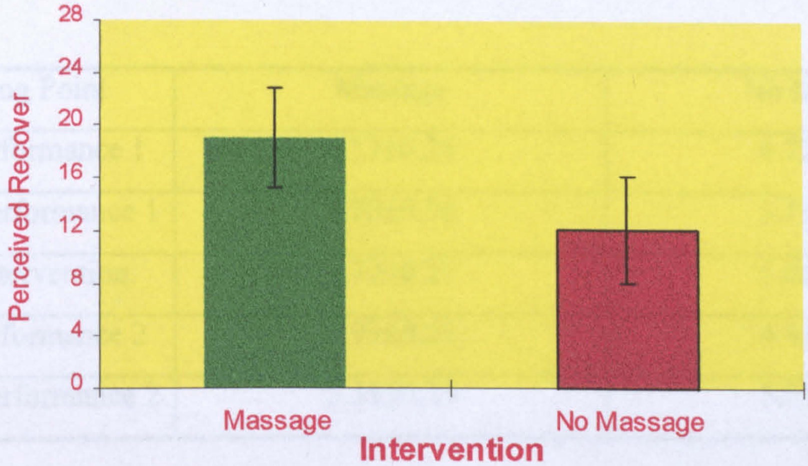


Figure 8.4.

Effects on perceived recovery in massage and no massage interventions



Blood Lactate and Glucose

Blood lactate and glucose means (±SEM) are shown in tables 8.4 and 8.5.

Table 8.4.

Mean (±SEM) Blood Lactate (mM) in Massage and No Massage Interventions.

Sampling Point	Massage	No Massage
Pre Performance 1	0.98±0.09	0.99±0.09
Post Performance 1	6.02±0.34	5.49±0.42
Post Intervention	1.87±0.10	2.19±0.26
Pre Performance 2	1.39±0.14	1.73±0.27
Post Performance 2	5.34±0.35	4.52±0.37

Table 8.5.

Mean (±SEM) Blood Glucose (mM) in Massage and No Massage Interventions

Sampling Point	Massage	No Massage
Pre Performance 1	4.57±0.25	4.72±0.19
Post Performance 1	5.70±0.36	5.19±0.28
Post Intervention	4.70±0.27	5.06±0.33
Pre Performance 2	3.99±0.22	4.43±0.30
Post Performance 2	5.31±0.23	5.06±0.21

Blood lactate and glucose were analysed via a Doubly Multivariate MANOVA. This showed a main effect for time, $\lambda = 0.04$ ($F_{8,54} = 25.52$, $p<0.001$). Examination of the separate univariate RM ANOVAS showed that both lactate ($F_{4,28} = 116.2$, $p<0.0001$) and glucose ($F_{4,28} = 5.29$, $p<0.005$) contributed significantly to the results. There was no main effect for intervention, $\lambda = 0.87$ ($F_{2,6} = 0.41$, $p>0.05$). A significant time by intervention interaction was found, $\lambda = 0.41$ ($F_{8,54} = 3.72$, $p<0.005$). Follow-up univariate analysis showed both lactate ($F_{4,28} = 5.68$, $p<0.005$) and glucose ($F_{4,28} = 3.72$, $p<0.05$) contributed to the results.

Post Hoc Tukey tests showed blood lactates were higher in the massage intervention than the no massage intervention at the post performance two sampling point. All other sampling points showed no differences between interventions. Post hoc analysis of blood glucose means revealed no differences between the massage and no massage interventions at each of the sampling points. Figures 8.5 and 8.6 show blood lactate and glucose levels at the various sampling points.

Figure 8.5.

Blood lactate values at each sampling point in massage and no massage interventions

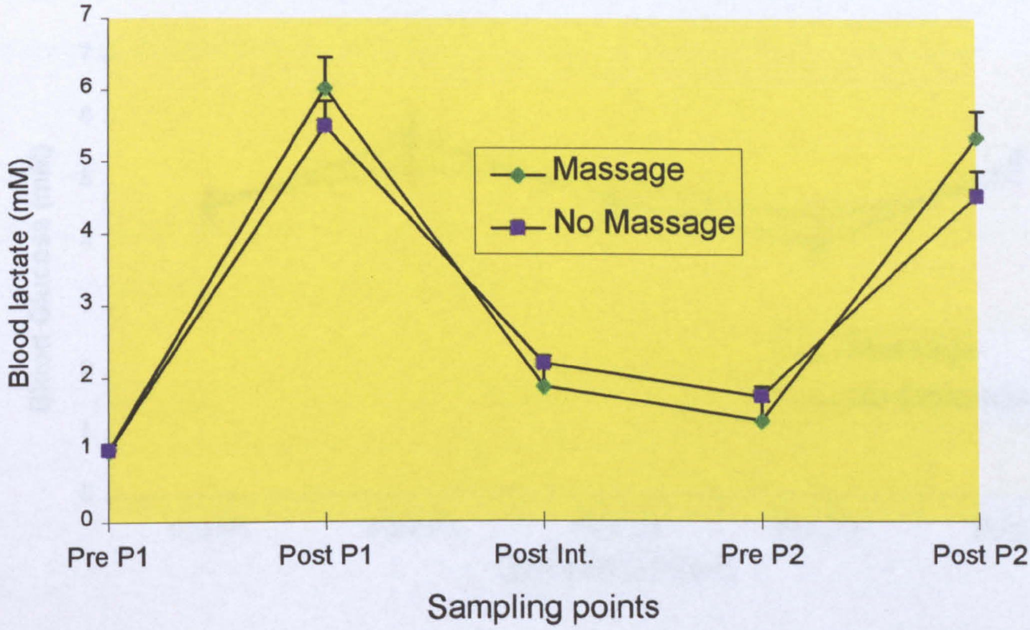
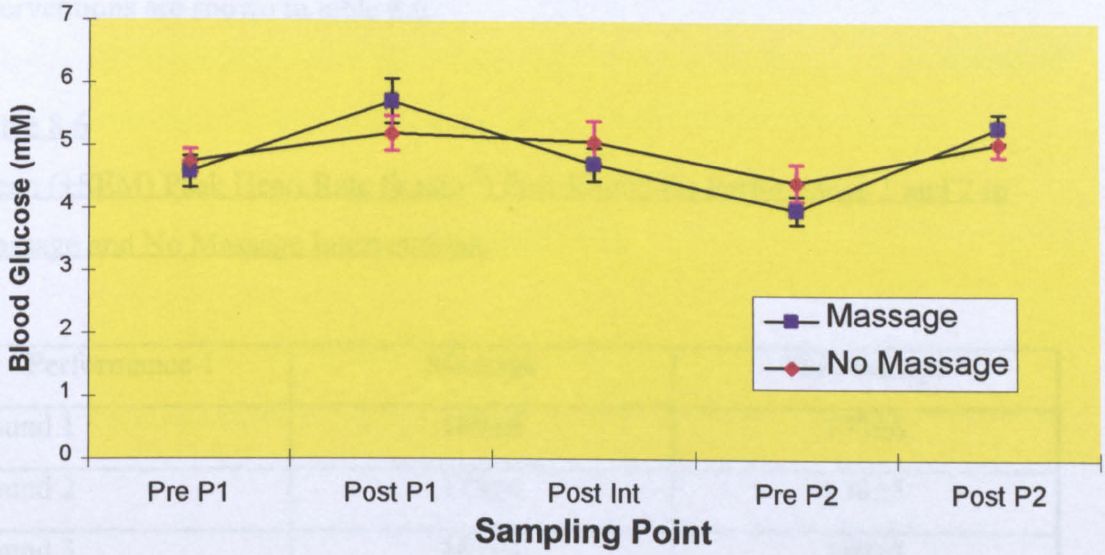


Figure 8.6.

Blood glucose values at each sampling point in massage and no massage interventions



Heart Rate

Heart rate means (±SEM) during performances 1 and 2 in massage and no massage interventions are shown in table 8.6.

Table 8.6

Mean (±SEM) Peak Heart Rate (b.min^{-1}) Post Round for Performance 1 and 2 in Massage and No Massage Interventions.

Performance 1	Massage	No Massage
Round 1	169±6	173±6
Round 2	178±4	178±5
Round 3	181±4	180±5
Round 4	183±4	181±5
Round 5	184±5	182±5
Performance 2		
Round 1	175±5	172±6
Round 2	180±5	179±6
Round 3	183±5	181±5
Round 4	185±5	183±6
Round 5	187±5	185±5

A 2 (intervention) X 2 (performance) X 5 (round) Repeated Measures ANOVA, with all independent variables as repeated measures showed a significant main effect for round (Round 1 < Rounds 2-5, $F_{4,28} = 44.35$, $p<0.0001$), but no main effects for intervention ($F_{1,7} = 0.4$, $p>0.05$) or performance ($F_{1,7} = 4.12$, $p>0.05$). No significant two-way or three-way interactions were found ($p>0.05$).

Psychological/Physiological Relationships

To assess the relationship between selected psychological and physiological markers, perceptions of recovery and fatigue and the post performance two blood lactate response were subjected to correlational analysis. This showed a non-significant relationship between perceived fatigue and the lactate response ($p>0.05$), however perceptions of recovery were significantly related to the lactate response ($r = .50$, $p<0.05$).

Discussion

The major finding of this study was that massage did not affect repeated sports performance. This supports the work of Drews et al. (1990) who found no change in repeated cycling performance following massage treatment. In contrast, Zelikovski et al. (1993) found massage with a pneumatic device led to a 45% improvement in subsequent treadmill running performance. The results showed a mean reduction in punching force in performance two in both conditions, hence in this case massage was unable to prevent a decrement in repeated performance. However, the finding of no difference between experimental conditions in performance two also supports the conclusions of Rinder and Sutherland (1995) that massage does not have detrimental effects on performance.

Nevertheless, it is also evident that whilst there was a significant decrease in performance two punching force, not all participants exhibited decrements in repeated performance. Three boxers registered increased punching force following the no massage condition, and two individuals showed greater punching force following massage. One boxer showed increased punching force in the second performance of both experimental conditions. Whilst it is clear that the majority of boxers exhibited decreased force in the repeated performances, the finding of individual variability following interventions may indicate that in terms of punching force, massage or passive rest may be the best form of recovery intervention for some individuals.

This individual variability appears to have contributed to a finding of no difference in punching force between conditions in the second performance. Whilst it is evident that there appears to be a trend in group means towards greater punching force in performance two following massage, it should also be noted that a similar trend of higher mean scores in the massage condition existed in performance one (with the exception of round one) prior to any intervention. This factor, together with a finding of no main effect for condition suggested that a further post hoc comparison between conditions at performance two was inappropriate. Moreover, the observed mean differences in punching force are argued to be so small that in practical terms they are of little value to the boxer.

It could also be argued that the experimental design utilised in this study may have contributed to the finding of no effect of massage on performance. It was noted in the review of literature that the possible positive effects of massage may have been overlooked in the Drews et al. (1990) repeated performance study when a substantial period of rest was also included. In other words, the athletes may have had sufficient time to recover without the need for massage intervention. In contrast, Zelikovski et al. (1993) found a 45% improvement in performance compared to a no massage condition when the repeated performance took place immediately post massage. It is clear that the same issue may have affected the results of this study. However, it was considered that the twenty minute massage routine was needed for consistency with recent studies focusing on exercise recovery (e.g. experiment five; Bale & James, 1991; Dolgener & Morien; 1993; Zelikovski et al., 1993), and with a minimum period of one hour separating domestic boxing contests, a further 35 minute rest period was required to retain this aspect of external validity.

Cafarelli and Flint (1993) have argued that much of the physiological basis of massage use in sport is guided by anecdotal evidence, hence this study also provides further scientific evidence of the influence of massage on physiological recovery from exercise. This research into the blood lactate response to massage supports the studies by Dolgener and Morien (1993), Gupta et al. (1996), and Zelikovski et al. (1993) who documented no differences between massage and passive rest conditions. Bale and James (1991) had found massage to lead to superior lactate removal than passive rest following running performance.

It is widely acknowledged that blood lactate is removed more quickly during active recovery because blood flow remains elevated through the active muscles, which enhances both lactate diffusion out of muscles and oxidation (Wilmore & Costill, 1994). Thus, the physiological basis upon which massage is argued to speed lactate clearance is by increasing blood flow (Ylinen & Cash, 1988). Whilst the exact effects of massage on blood flow are still being debated (Dubrovsky, 1983, 1990; Shoemaker, Tiidus & Mader, 1997; Tiidus & Shoemaker, 1995), blood flow was not measured in this study. Nevertheless, the present finding of no effect of massage on blood lactate would suggest that either blood flow was not affected, or conversely, that it was not increased sufficiently to enhance lactate clearance.

The inclusion of a touching control condition to investigate the psychological response to massage was not deemed necessary following the results of experiment five charting massage effects in the post training period. However, the discovery that perceptions of fatigue and recovery also showed significant changes following massage following a simulated boxing performance closely replicates the findings of experiment five. A number of authors have argued that the benefits of massage are more psychological than physiological (Boone et al., 1991; Cafarelli & Flint, 1993; Harmer, 1991; Tiidus & Shoemaker, 1995), and the finding of no physiological effects in this study supports such claims. Some participants in this study remarked that they felt "looser", "not as heavy" and had "lighter legs" following massage, which also seem to document heightened feelings of recovery. Nevertheless, these perceptions were not accompanied by greater performance than that seen in the no massage condition.

An interesting finding in this study compared with with experiment five involved the mood state vigor. Similar to the work of Weinberg et al. (1988), the previous experiment had shown no effects of massage on this mood state, although there were non-significant decreases seen in massage and control conditions following training. In contrast, this study showed perceptions of vigor to significantly increase following interventions. An explanation for this reversal may lie in the performance task that was awaiting participants. In experiment five no further training was required after the interventions and hence the boxers vigor scores may have reflected thoughts that training had finished for the day, whereas in this study the increase in post intervention perceptions of vigor may have been due to some form of mental preparation for the next performance simulation which was approaching.

The need for interdisciplinary research to explain aspects of recovery has been highlighted, and the combination of psychological and physiological measures used in this investigation may shed greater light into the result of significantly higher blood lactate being found after performance two in the massage condition; a finding which could not be explained by differences in the avaliability of glucose an energy source between conditions. Here, it could be argued that the psychological benefits gained through massage may have resulted in boxers expending greater physical effort in the second performance. Correlational analysis partially supports such a proposition, with perceived recovery being significantly related to the post performance two blood lactate ($r = .50$). It could be contended that sub-maximal heart rates should have also been significantly elevated if there was greater physical effort in the massage condition second performance. However, there were non-significant increases in heart rate in this condition and it is possible that as boxers were working within the physical constraints of the punching protocol, and with heart rates relatively high, significant changes in heart rate were unlikely.

If the contention that greater effort was expended in the repeated performance following massage is momentarily accepted, the question which immediately arises is why there were no accompanying changes in performance. A possible explanation could lie in the performance measure gained through use of the boxing ergometer. It is evident that boxing performance in a competitive bout entails far more aspects that can be replicated in a laboratory study. For instance, though the ergometer permits an ecologically valid punching protocol, the attributes of dynamic footwork, speed, feinting and defence are clearly not easily measured. Suitably, it may be that the force of punch used as the dependent variable in this study, requires skill, technique and stamina, and as such may not be sensitive enough to benefit from any psychological benefits of massage. Moreover, the hypothesised greater effort may have been channelled into aspects of boxing performance which were not measured. For instance, it is possible the boxers were generating more punching force following massage, but this force may have been directed into the two (Fx and Fy) force planes which were not measured in this study.

In other words, more force may have been produced, but it was less accurate in terms of the target area. Alternatively, a more gross physical effort based performance measure may have yielded significant results similar to those recorded by Zelikovski et al. (1993) who used a treadmill run to exhaustion as the performance measure. On this note, if the force of punch is not an entirely suitable measure, it would have been interesting to remove the constraints of an eighty punch protocol and examine if perceptions of recovery led to an increased number of punches thrown in a two minute round. Nonetheless, the positive proposition that massage may have led to increased effort in performance two (shown in the elevated post performance two blood lactate) could also be challenged by a radically different negative alternative. For instance, it could be suggested that the massage treatment may have been detrimental in some way physiologically, and as such required the boxers to work physically harder in the second performance to achieve the same punching force as that seen in the no massage experimental condition. It is contended however, that this is an unlikely explanation when one considers the boxers' perceptions of recovery measured quantitatively and their additional comments following massage.

The finding that punching force was significantly lower in round one compared to rounds two to five could be explained by an insufficient warm-up by the boxers in this study. Heart rate data showed lower values in round one compared to later rounds which also indicates that the self-selected routine chosen by boxers did not adequately prepare them for the performance ahead. In practical terms, this information is useful to boxers and coaches alike, as it demonstrates the force of punch can be compromised in the early part of a contest if the warm-up is any way neglected.

Whilst it has been highlighted that the performance measure chosen in this study has possible limitations, the heart rate and blood lactate response to the five 2 minute rounds bout simulation showed figures which seem to replicate the preliminary findings collected in the field. The blood lactate values appear to be at the lower end of the 5-10 mM range seen in international boxers after competitive bouts. Nevertheless, it is recognised that the boxers in this study were not elite, and this fact paired with the obvious difficulties in fully replicating a combat sport in the laboratory setting, suggests that for the purpose of this study, the punching protocol imposed sufficient physiological stress on the boxers.

In conclusion, this study has documented further evidence of psychological regeneration following massage. However, the efficacy of massage for promoting blood lactate clearance following boxing performance has been questioned, as has the use of massage as a performance enhancement modality in terms of punching force in amateur boxing. Finally, it has been suggested that some relationship may exist between the proposed psychological benefits of massage in the recovery phase and aspects of repeated sport performance.

Chapter 9

Discussion and Conclusions

The discussion and conclusions will be split into sections that focus separately on the aims of the research; the mood profiling of amateur boxers during training, the S-IgA/saliva flow response in amateur boxers during training, and the effects of massage on regeneration, recovery and performance in amateur boxing. In each section, the main findings will be briefly stated, followed by potential limitations of the research, the practical implications and recommendations for future directions of study. Similar to the structure of the review of literature, a further section will briefly emphasise the benefits of an interdisciplinary approach to training stress and recovery in boxers. Finally, a short summary will outline the specific conclusions drawn from the research.

Mood Profiling of Amateur Boxers During Training

The main finding which has arisen from field based investigations is that amateur boxers experience mood disturbances with intensified training. Congruent with previous research using mood profiling for monitoring the training status of athletes in endurance sports (e.g., Morgan et al., 1987) and mixed endurance sports (Raglin, 1995), the mood states vigor and fatigue were seen to show the largest changes. The mood states of anger and tension also demonstrated negative changes, with the disturbances in tension-related affect being possibly linked to cognitive concerns about competition. In contrast, the mood states depression and confusion showed no change with different training loads. Furthermore, whilst the first study utilised the original POMS (McNair et al., 1971), a subsequent investigation showed these mood state changes were closely replicated when boxers were monitored via a sport specific, 21 item, five subscale version (confusion subscale omitted).

A potential limitation of the studies focusing on mood state monitoring (and subsequent S-IgA analyses) during boxing training was that mood disturbances were only documented in one small group of boxers in an applied setting. Hence, the problem of small sample sizes and the possibility of reduced experimental control in applied research (Thomas & Nelson, 1996) may limit the generalisability of the findings to all amateur boxing training. However, the training loads and methods focused upon in the research were seen as typical of those used by amateur boxers, thus the results suggest boxing training can have negative psychological effects, and that mood state monitoring would appear to be a worthwhile exercise.

In this research, it was felt that the boxing specific, modified POMS provided a more sensitive tool for the measurement of training responses in boxers. Gauvin and Russell (1993) have argued that there is an ongoing problem in psychometric testing in sport psychology, whereby the need for practical utility has led to the development of increasingly situation and population specific tests. However, these authors also recognised the need for researchers to have instruments for very specific purposes and narrow settings. The rationale for the development of the boxing specific mood measure originated from potential cultural and interpretational problems associated with the original POMS and the need to answer a specific applied research problem. Hence, the development of a psychometrically sound, alternative and specific inventory in this case seemed to be justified.

Nevertheless, it would be erroneous not to highlight the potential limitations of using the boxing specific POMS with other groups or in different contexts. Whilst the modified POMS demonstrated acceptable psychometric properties in the present study, cross-validation of these results is desirable. All of the participants used in the study were adult male boxers, and the sample size used in the construction of the shortened version was relatively small. It has been highlighted that measurement scale validity can be highly situation specific (American Psychological Association, 1985). Thus, whilst the instrument showed good reliability data and the ability to demonstrate mood changes over different training loads, different findings could emerge in studies involving youth boxers, female boxers, and/or in other competitive environments. Suitably, larger studies incorporating male, female, senior, and junior boxers may be needed to further refine the instrument if it is to be used in a different context.

The practical benefits of monitoring boxers during intensive training loads, and the importance of the maintenance of psychological well-being during training was stressed earlier in this thesis. The results of experiments five and six which focused on psychological regeneration following boxing training and performance suggest that massage may be an effective technique to incorporate into boxer training programmes to guard against perceptions of fatigue and maintain well-being. However, the present research only demonstrated acute perceived fatigue and recovery responses in a small group of amateur boxers, hence these benefits of massage need to be replicated over longer periods in larger groups of intensively trained athletes.

Additionally, whilst future research needs to explore further the positive effects of massage on psychological well-being in the post training period, massage should not be regarded as the only form of intervention which may combat training stress. Future study could also be targeted at other techniques through which boxers could maintain psychological well-being during intensive training. One such method for boxers may be increased emphasis on mental skills prior to the commencement of, and during, training schedules. The cognitive appraisal approach to training stress suggested by Spargo and Horsley (1994) implied that athletes would experience mood disturbance if training demands were perceived to outweigh coping resources. It was also argued that mood disturbance could subsequently lead to decreased effort by athletes in order to lessen the perceived demands of continued intensive training. This approach seems intuitively appealing, and may reflect the anecdotal accounts of England boxing coaches who often express concerns about boxers "going through the motions", "taking their foot off the pedal" or "feigning injury" to reduce effort or conserve energy during intensive training regimens .

This cognitive appraisal approach to effort expended in training evidently has close connections with the psychological components of perceived exertion described by Morgan (1994). After establishing that the sensation of effort or perceived exertion was a psychophysiological construct, Morgan (1994) cited empirical evidence which suggested simple self-report ratings of effort sense were as effective as more conventional physiological and psychological markers in monitoring distress in athletes during intense training. Moreover, the psychological interventions proposed to modify perceived exertion such as imagery, hypnosis and dissociative cognitive strategies (Morgan, 1994) could have implications for boxers exposed to extreme training loads.

Here, it could be suggested that boxers might use psychological skills in order to prepare themselves for the rigorous training demands which are a necessary part of competition preparation. For instance, whilst internal imagery has led to an increase in effort sense in a physical task (Wang & Morgan, 1992), it is possible that this cognitive strategy could be used by boxers to decrease perceptions of effort when undergoing intense training. Likewise, the use of a dissociative cognitive strategy has led to a decrease in effort sense in endurance performance (Gill & Strom, 1985, Morgan, Horstman, Cymerman & Stokes, 1983; Weinberg, Smith, Jackson & Gould, 1984), hence the use of dissociation strategies by a boxer in heavy training could result in increased tolerance to the training demands and potentially less mood disturbance.

The use of hypnosis as a moderator of effort sense also could have an impact on a boxer's perception of effort during training. It has been demonstrated that the perception of effort in physical tasks can be increased or decreased by administering hypnotic suggestions of easier or more difficult work (Morgan, Raven, Drinkwater & Horvath, 1973; Morgan, Hirota, Weitz & Balke, 1976). Suitably, if mood disturbance during training is partly a consequence of cognitive appraisal of perceived demands and resources as Spargo and Horsley (1994) suggest, then a range of cognitive strategies may provide boxers with increased coping resources to manage the training demands. However, it must be emphasised that the successful use of these strategies in the training context has not been documented, hence research is necessary to discover if they are applicable to boxers undergoing intensive training.

Furthermore, Miller, Vaughn and Miller (1990) have discussed the benefits of various stress management techniques in dealing with stress-oriented athletes, and presented a four stage model including behavioural assessment, cognitive appraisal, education and training, and stress management skills. It is possible that this model could be applied to help boxers sustain, and cope with, intensive training schedules. In this context, the behavioural assessment phase would involve an analysis of the variety of components of stress experienced by a boxer in training. In the cognitive appraisal phase, the aim would be to assess the process of cognitive interpretation of stressful events during training and to identify the self-statements that emphasise a boxer's inability to cope. During the education phase, time would be spent with boxers to prepare them for the anticipated stress which would arise in training, and to identify what triggers the stress or mood disturbance. Finally, a range of stress management techniques such as relaxation and imagery could be taught to equip boxers with skills to utilise when placed under training stress. Whilst this model would seem to offer a sound intervention for boxers undergoing training, empirical research needs to clarify the effectiveness of the model in boxers in the applied setting.

Another method of maintaining psychological well-being could be through a reduction in workloads during training. The balancing of workloads as a consequence of mood profiling was proposed by Morgan et al. (1987; 1988) and was reported to be a successful strategy in the preparation of Swedish Olympic canoeists prior to the 1992 summer games (Burglund & Safstrom, 1994), and in the training of an elite swimmer (Mahoney & Kremer, 1993, cited in Terry, 1995). Whilst the titration of workloads with boxers was not examined in this research, this method has some empirical support, and may offer coaches and boxers a collective approach to maintaining psychological well-being during training.

In summary, the range of mood disturbances seen in boxers during training was lessened by the use of massage in the post training period. However, further research is needed to replicate the positive effects of massage over longer time periods, and future research should also embrace the study of other interventions aimed at lessening or preventing mood disturbance in boxers during training. The balancing of workloads through mood profiling seems to offer a promising avenue of study, and if one assumes the role of cognitive appraisal during training, the potential for mood disturbances to be minimised through the use of various psychological skills is worth exploring. Whilst the thrust of recent papers suggesting future research into the use of the POMS to monitor for indications of overtraining have focused on intra-individual changes in mood state (Terry, 1995) and the role of the total mood disturbance score (Hooper, MacKinnon & Hanrahan, 1997), it is argued that research should also attempt to test empirically the effectiveness of various interventions designed to combat the mood disturbances experienced during intense training, rather than simply monitoring for the occurrence of such disturbances.

Salivary IgA/Saliva Flow in Amateur Boxers During Training

The main finding from investigations into the immunological status of boxers undergoing training was that repeated interval training led to a decrease in S-IgA, this being principally due to a reduction in saliva flow rate. Boxers were also seen to have unusually low saliva flow rates compared to sedentary age-matched individuals. Furthermore, reduced saliva flow was strongly related to weight loss during training. These factors were argued to be detrimental to salivary aspects of acquired and innate immune function in boxers.

It is evident that the S-IgA response to exercise has generated much research and the role of saliva flow has been recognised as important in determining S-IgA measurements (e.g., MacKinnon et al., 1993a, 1993b). However, only recently has it been suggested that drying mucosal secretions can also have potentially detrimental effects on innate immune function (Peters, 1997). Moreover, the data arising from this research suggest that boxers may compromise their innate immune system defence (via reduced saliva flow) against URTI if they use dehydration strategies in order to make competition weight. Whilst the dangers of dehydration for the boxer's health and performance have been the subject of previous coach and boxer education work (Smith, 1993), the potential effects on immune function have been previously overlooked. Nieman (1997) has advised athletes to lose weight slowly during training in order to guard against immune suppression, hence future education work may also need to highlight the effects of rapid weight loss on protection against URTI. Additionally, future research needs to assess the saliva flow rates and S-IgA secretion rates in other weight-classified sports to clarify the possible detrimental immune effects faced by athletes in weight-controlled environments.

Various authors (e.g., Brenner et al., 1994; Nieman, 1997) have proposed preventative measures to reduce the risk of infection in athletes, such as minimising exposure to pathogens, monitoring the training plan, maintaining an adequate diet, and the use of regenerative strategies. Nevertheless, it was argued in chapter six that combating dehydration and low saliva flow rates in a weight classified sport such as boxing may not sometimes be an option for most competitors. Whilst it seems probable that maintaining fluid availability through well controlled weight loss may be the best form of prevention, other strategies may help stimulate saliva flow and therefore increase innate protection against URTI.

For instance, although this research showed that massage as an intervention (Green & Green, 1987) did not increase saliva flow following training perhaps due to the hydration status of boxers, recent research by Miletic et al. (1996) suggests that simple stimulation of saliva flow through citric acid can correct S-IgA secretion rate deficits, and hence provide an individual with increased protection against URTI. This manipulation of saliva flow leading to improved S-IgA secretion rate would have obvious implications for both the innate (saliva flow) and acquired (S-IgA) responses of boxers in training. Nevertheless, it must be recognised that the manipulation of saliva flow has received little interest in immunological research, and furthermore, has not been demonstrated to be successful in athletes who may be dehydrated. Therefore, its effectiveness as a corrective or preventative strategy in this context is unknown.

The use of S-IgA in this research as a measure of immune function provided additional insights into the effects of training stress in boxers. MacKinnon (1992) has listed the benefits of the use of S-IgA over the measurement of T and B immune cells in the blood. Notably, compared to blood tests, saliva is argued to be easy to collect and without risk to the participants under study, and moreover, the findings in saliva can be generalised to the whole mucosal immune system (Miletic et al., 1996). Considering the vital primary role played by the mucosal immune system in the defence against URTI (MacKinnon et al., 1993a), it would seem that there is a sound rationale for using salivary analysis in this research, and that it affords an effective immunological measure in boxers. Nevertheless, although the ELISA technique (Engvall & Perlmann, 1971) is widely adopted as the gold standard in S-IgA measurement, Miletic et al. (1996) have noted that immunological assays are complex and the processes involved are open to error, and this may limit the generalisability of the results. This factor also suggests that the comparison of S-IgA found in boxers with those found in other sports should also be read with some caution.

Finally, it is clear that the much hypothesised relationship between athletic participation and URTI (e.g., Fitzgerald, 1991; Weidner, 1994) is still based to some degree on epidemiological studies (e.g., Peters & Bateman, 1983). This research has not sought to document the incidence of URTI in boxers undergoing training due to the fact that self-reported symptoms of infection were deemed problematic (Heath et al., 1992). However, the findings suggest that some boxers may have increased susceptibility to URTI through reduced S-IgA and saliva flow. Clearly, it would seem a worthwhile avenue for future research to incorporate some form of physician diagnosis (Heath et al., 1992) to document the occurrence of such infections in boxers during training.

Massage Effects on Regeneration, Recovery and Performance in Amateur Boxing

Massage is often used in an attempt to counteract the unpleasant sensations which accompany strenuous physical exertion, as well as to speed the recovery process and increase performance (Ylinen & Cash, 1988; Cash, 1996). The main finding of this research was that massage led to psychological regeneration in the form of decreased perceptions of fatigue and increased perceptions of recovery when compared to touching control and lying resting conditions following boxing training, and the same psychological changes were replicated after a boxing performance. However, massage was not seen to influence saliva flow, nor did it affect blood lactate clearance or boxing performance in the final laboratory investigation. These findings support the claims of Boone et al. (1991), Harmer (1991) and Tiidus and Shoemaker (1995) who proposed that the effects of massage were more psychological than physiological, and that there is an absence of evidence to suggest massage increases physiological recovery and performance (Cafarelli & Flint, 1993).

It is clear that despite numerous authors recommending the use of passive recovery strategies (e.g., massage, hydrotherapy, sauna, flotation tanks) during athlete training programmes (e.g., Brenner et al., 1994; Hardy, Jones & Gould, 1996; Miller et al., 1990; Morris & Summers, 1995; Shephard & Shek, 1993), little is documented scientifically about their effects. In short, it would appear that though passive recovery strategies are widely used, they are still poorly researched and understood. However, the later studies in this research suggest that preliminary support can be given to the vast amount of anecdotal evidence suggesting positive psychological effects of massage as a regenerative strategy.

Unfortunately, the nature of the mechanisms involved in this regeneration process are still not known, with the documented effects on perceptions of fatigue and recovery, and accounts of "feeling looser" not being readily explainable. Furthermore, there is little documented in past research which specifies the process by which massage can enhance psychological well-being. Cafarelli et al. (1990) have suggested that the psychological benefits of massage may be due to a soothing of central and peripheral nerves, although these authors give no account of what "soothing" of nerves precisely means or how it occurs. Another neural explanation was expressed by Longworth (1982), who proposed decreased arousal levels via reduced neural input to explain the sensation of well-being in nursing patients following massage. Additionally, Kaada and Torsteinbo (1989) reported a 16% increase in plasma endorphin concentration and suggested that the release of endorphins may be the mediating factor in the sensation of well-being following massage. However, the latter results were gained through the use of connective tissue massage, which is a different form of massage to that used in this research. Suitably, the endorphin response may not be a viable explanation for the psychological changes witnessed in boxers.

It must also be noted that whilst most boxers reported that they felt better as a result of massage, many of these reports are very subjective and difficult to substantiate empirically. For instance, it was common for boxers to express "feeling looser" or "less heavy". While the inclusion of four additional self-report items attempted to chart other aspects of perceptions of recovery and generated some interesting findings, this measure may have limitations and should be seen as in the early stage of development. Undoubtedly, the current items included in the perceived recovery analysis need to be tested further and perhaps extended to explore more aspects of perceptions of recovery. Additionally, there is currently no methodology for measuring the "feeling looser" or "less heavy" constructs. These elements would need to be addressed in future research into the psychological effects of massage, and it may be that the collection of qualitative data following massage could provide a richer understanding in this respect.

The belief that accumulated lactate is at least partially responsible for retarding recovery from fatigue (MacClaren et al., 1989; Maughan et al., 1997), and the known effect of blood flow for increasing lactate oxidation and diffusion out of muscles (Bonen & Belcastro, 1975; Dodd et al., 1984; Gaesser & Brooks, 1984; Hermansen, 1981) has prompted research into the effects of massage on lactate removal. However, the finding in this research that massage did not result in more efficient lactate clearance than passive rest suggests that the use of massage as a physiological recovery strategy is highly questionable.

Nevertheless, it should be highlighted that there are other physiological markers of recovery upon which this research has not focused which may benefit from massage intervention. For example, it is known that during and after exercise there is an accumulation of fluid in the muscle and interstitial space (Sejersted, Vollestad & Medbo, 1986; Sjogaard & Saltin, 1982) and it has been suggested that this factor could inhibit muscle function (Sjogaard, Savard & Juel, 1988). Significantly, it has been proposed that massage could result in the removal of excess muscle fluid after exercise (Zelikovski et al., 1993), though at present this hypothesis appears to have been untested. To conclude, therefore, it seems there is presently little compelling evidence to support the widespread claims that massage can be an effective modality for enhancing physiological recovery from boxing performance, or exercise in general.

The results of this research also suggest little effect of massage on boxing performance, at least not in terms of punching force. Cafarelli and Flint (1993) have stated that there is little empirical evidence which demonstrates performance benefits of massage, though these authors recognised this was an under researched area. Whilst positive effects of massage on sports performance still remain questionable, this research has raised some interesting issues in terms of how performance should be measured. It was argued that although use of the boxing ergometer enabled greater ecological validity and the collection of reliable punching force data, there may have been non-measured aspects of performance which may have been affected by the massage intervention. Indeed, closer analysis of boxer movement and the measurement of force in all three planes may help reduce any limitations in the performance measure, and hence clarify the relationship between massage and boxing performance in future studies.

It is also clear that if massage and other recovery strategies are to be the subject of future research, then attempts must be made to standardise techniques across studies. Callaghan (1993) has noted that the length of time and type of massage used are often based upon the preference of the researcher rather than scientific rationale in the laboratory setting. Since the available literature is not universal regarding the duration of massage (Gupta et al., 1996), the protocol used in this research replicated the duration used in recent studies on massage and exercise recovery (Bale & James, 1991; Dolgener & Morien, 1993; Viitasalo et al., 1995; Zelikovski et al., 1993). Hence, while it is evident that the number, length and pressure of massage stoke are virtually impossible to reproduce across studies, some aspects of massage routines may be replicated in future research.

Future research may also wish to explore other uses of massage beyond that of exercise recovery. Weinberg et al. (1988) have listed other periods when athletes could benefit psychologically from massage such as before and after competition. Weinberg and Gould (1995) have commented on the importance of assisting athletes to recover from the psychological stress placed on them during competition, and it may be that massage is a suitable technique to help athletes cope with the stresses of a recent performance. Undoubtedly, there is a need for direct evidence with regard to the role of massage for improving or maintaining psychological well-being in competitive sport settings.

Benefits of an Interdisciplinary Approach to Training Stress and Recovery in Amateur Boxers

The need for interdisciplinary research into the training stress field has been identified by Weinberg (1990) and McCann (1995). Whilst the monitoring of mood in tandem with physiological factors has been the subject of some study (e.g., Morgan et al., 1988; O'Connor et al., 1989; 1991), only recently have authors indicated possible links between mood states and immunological measures in athletes during training (MacKinnon & Hooper, 1994; McCann, 1995). Whilst this research did find adverse changes in both mood states and S-IgA, there was no evidence of a relationship between mood and S-IgA across a boxing season. Nevertheless, the fact that only a small sample size was utilised, with relatively few data collection points may indicate that the link between mood and salivary aspects of immune function in training could be further explored in future studies using greater numbers of participants and more frequent analyses.

The need for an intervention to combat the ill effects of boxing training documented in the first four studies also afforded the opportunity of interdisciplinary research into the effects of massage. In experiment five, a concurrent evaluation of saliva flow rates, mood states and perceptions of recovery demonstrated that knowledge from various disciplines could be integrated and applied to boxers in a realistic sport situation, with the goal of solving a specific problem.

Likewise, the final experiment also provided an excellent opportunity to integrate psychological, physiological and performance measures in a co-ordinated fashion to examine the effects of massage in an ecologically valid boxing task. Indeed, the benefits of simultaneously measuring these aspects were demonstrated in raising psychological explanations for the increased blood lactate concentrations in the massage condition following the second boxing performance. It is quite clear that these explanations, though tentative, would carry less weight if a monodisciplinary approach had been taken. It is apparent from previous research into the performance effects of massage that authors have somewhat conveniently cited unmeasured psychological benefits in the absence of measured physiological changes to explain improved performance (Zelikovski et al., 1993), hence this study provided a more complete analysis in this respect.

It was argued earlier in this thesis that an interdisciplinary perspective would need to be adopted to grasp more fully the processes underlying the problems faced by boxers during training. Weinberg (1990) has suggested that an interdisciplinary approach is desirable in that sport scientists can study the athlete as a whole rather than just focusing on a single discipline. Whilst it is recognised that monitoring psychological and immunological measures in amateur boxers during training may still fall somewhat short of studying the boxer as a "whole", this monitoring did allow theoretically relevant variables to be studied in unison rather than in isolation (McCann, 1995). Moreover, encompassing both measures in a realistic, applied sports situation enabled a further understanding of the mechanisms and processes behind the anecdotal accounts of mood disturbance and increased infections seen in boxers in the training environment.

Summary

A series of field based investigations allow the following conclusions to be made:

- Amateur boxers experience mood disturbances during intensified training, which supports the anecdotal accounts of England boxing coaches in the field. The mood states vigor and fatigue showed the largest changes, with tension and anger also showing negative changes. In contrast, the mood states depression and confusion showed no signs of disturbance. These results suggest that training stress may be a problem for boxers, and furthermore, that mood profiling during boxing training is a useful monitoring exercise.

- The mood disturbances documented with the original POMS (McNair et al., 1971) were replicated through the construction and use of a sport specific shortened POMS. This alternative inventory was shown to demonstrate acceptable psychometric properties and was suitable for monitoring mood states in amateur boxers during training.

- The immunological status of amateur boxers during training was monitored via S-IgA. An initial study of boxers over a season showed no reductions in S-IgA in heavy training periods, however saliva flow rates were unusually low. Follow-up analysis of age-matched sedentary individuals showed that boxers saliva flow rates were significantly lower in comparison.

- Acute, but not cumulative reductions in S-IgA were found following repeated interval boxing training over one week, with the reductions principally due to decreases in saliva flow. Additionally, the reductions in saliva flow were strongly related to weight loss in boxers in the same seven day period. Low saliva flow rates and reduced S-IgA indicate the potential for increased susceptibility to upper respiratory infection in amateur boxers.

- Massage resulted in decreased perceptions of fatigue and increased perceptions of recovery compared to control conditions following boxing training. However, in the same study, massage did not lead to increased saliva flow rates. These results suggest the efficacy of massage as a regenerative technique in the post training period.

- The same psychological benefits of massage were demonstrated in the final experiment, though massage did not result in more effective blood lactate clearance compared with a no-massage condition. Similarly, massage did not lead to improved punching force in an ecologically valid boxing task. These results provided further evidence of the regenerative effects of massage, but question the use of massage for physiological recovery and as a performance enhancement modality.

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Appendix 1

Boxing Modified and Shortened POMS, and Perceived Recovery Items

NAME: ------------------------ DATE: --------------

Please rate according to how you feel RIGHT NOW

Circle ONE box for each item

	NOT AT ALL	A LITTLE	MODERATELY	QUITE A BIT	EXTREMELY
1. Worn Out	0	1	2	3	4
2. On Edge	0	1	2	3	4
3. Sad	0	1	2	3	4
4. Angry	0	1	2	3	4
5. Need a Rest	0	1	2	3	4
6. Energetic	0	1	2	3	4
7. Tense	0	1	2	3	4
8. Worried	0	1	2	3	4
9. Miserable	0	1	2	3	4
10. Down	0	1	2	3	4
11. Fatigued	0	1	2	3	4
12. Annoyed	0	1	2	3	4
13. Active	0	1	2	3	4
14. Relaxed	0	1	2	3	4
15. Lively	0	1	2	3	4
16. Unhappy	0	1	2	3	4
17. Tired	0	1	2	3	4
18. Bad -Tempered	0	1	2	3	4
19. Anxious	0	1	2	3	4
20. Alert	0	1	2	3	4
21. Irritable	0	1	2	3	4

Please also rate how you feel RIGHT NOW on the following:

CIRCLE ONE NUMBER

	NOT AT ALL						VERY MUCH SO	
Refreshed	0	1	2	3	4	5	6	7
Rested	0	1	2	3	4	5	6	7
Recharged	0	1	2	3	4	5	6	7
Recovered	0	1	2	3	4	5	6	7

Appendix 2

Boxing Performance Punching Protocol (80 punches per 2 min. round)

Seconds	Punch Combination	Seconds	Punch Combination	Seconds	Punch Combination
1	2	41		81	Left
2		42		82	
3		43	Right	83	
4		44		84	3
5		45		85	
6	2	46	3	86	
7		47		87	2
8	Left	48		88	
9		49		89	
10		50	Left	90	3
11	Right	51		91	
12		52		92	
13	2	53	2	93	2
14		54		94	
15		55		95	
16	3	56	3	96	3
17		57		97	
18		58		98	Left
19	Left	59	Left	99	
20		60		100	3
21		61		101	
22	Right	62	Right	102	
23		63		103	
24		64		104	2
25	2	65	3	105	
26		66		106	
27		67		107	Left
28		68	2	108	
29	Left	69		109	
30		70		110	3
31		71	3	111	
32	3	72		112	
33		73		113	3
34	2	74		114	
35		75	3	115	
36	2	76		116	Left
37		77		117	
38		78	2	118	
39	Left	79		119	3
40		80		120	

Note:- Two punches consisted of a left and right punch combination. Three punches consisted of left, right, left. All of the participants were orthodox (right-handed) boxers.

Appendix 3

MOOD STATE MONITORING IN AMATEUR BOXING TRAINING.

Most research on overtraining in sport psychology has focused on endurance sports employing the mood state monitoring approach established by Morgan, Brown, Raglin, O'Connor and Ellickson (1987, *British Journal of Sports Medicine*, **21**, 107-114). However few studies have followed the mood response in mixed endurance sports training. Murphy, Fleck, Dudley and Callister (1990, *Journal of Applied Sport Psychology*, **2**, 34-50) have also suggested that combative athletes (e.g. judo, karate, boxing, wrestling) may show a different psychological make-up to non-combative athletes, and hence exhibit less mood disturbance during intensive training phases. No psychological research exists on amateur boxing training, hence the aim of this study was to investigate the mood response during different amateur boxing training phases.

Royal Navy Boxing Squad members (N=8) completed a slightly modified Profile of Mood States (POMS; McNair, Lorr & Droppleman, 1971: *Manual for the Profile of Mood States*. San Diego, CA:EdITS) in four training phases over a two month period in preparation for a major annual championship. Four POMS items were changed in an attempt to make the inventory more culturally specific for use by British athletes. The training phases were light intensity (LI), medium intensity (MI), high intensity (HI) and taper (T).

A series of one-way ANOVAS, with time as the repeated measures factor, revealed differences in tension ($F_{3,21} = 30.23$, $p<0.001$), anger ($F_{3,21} = 12.79$, $p<0.001$), vigour ($F_{3,21} = 49.03$, $p<0.001$) and fatigue ($F_{3,21} = 51.57$, $p<0.001$). No changes over time were found in depression or confusion subscales ($p>0.05$). Post hoc Tukey tests showed no significant differences between LI and MI in any POMS subscale. Tension, anger, vigour and fatigue showed significant negative shifts in HI, with tension, vigour and fatigue exhibiting significant positive shifts towards LI/MI levels in T. Anger returned to LI/MI levels in T.

These findings suggest that amateur boxers are prone to mood disturbances in training and show comparable disturbances to those seen in other sports. Moreover, the boxers in this study did not appear to peak psychologically after increased sport-specific training, perhaps indicating an insufficient taper period. Elevated levels of tension in the taper phase may also represent cognitive-perceptual concerns about the approaching competition. The absence of a disturbance in levels of depression suggests overtraining may not be a problem in sub-elite amateur boxing training. Further research into the effects of increased training volume in elite amateur boxing is warranted.

THE EFFECTS OF REPEATED INTERVAL AMATEUR BOXING TRAINING ON SALIVARY IMMUNOGLOBULIN-A.

Intensive exercise may be immunosuppressive with a concomitant decrease in salivary immunoglobulin-A (S-IgA) levels (Fitzgerald, 1991, *International Journal of Sports Medicine,* **12**, S5-S8). Mackinnon *et al.*(1993, *European Journal of Applied Physiology*, **67**, 180-184) have argued that salivary flow needs to be considered to ascertain a more biologically relevant picture of the S-IgA/exercise relationship, and have shown a cumulative effect of repeated interval training on S-IgA secretion. Amateur boxing training has not been subjected to immunological research and immuno-suppression may be a problem during intensive interval boxing training. This study examined acute and cumulative effects of repeated interval sessions on S-IgA levels and also sought to investigate the importance of salivary flow in a weight-classified sport.

Seven sub-elite amateur boxers (mean ± S.D.) age 23±2.6 years, were assessed immediately before and after three interval training sessions, which were undertaken over a seven day period during the course of a normal training programme. Unstimulated 4-min. whole saliva samples were taken immediately prior to and upon completion of the sessions which lasted 45-60 mins. Sessions began at the same time of day in each case. The samples were immediately frozen at -20°C and were later assayed for S-IgA concentrations using ELISA (Engvall & Perlmann, 1971, *Immunochemistry*, **8**, 871-874). The S-IgA secretion rates were calculated from salivary flow rates and S-IgA concentrations.

Table 1
S-IgA concentrations, S-IgA secretion rates and salivary flow rates (mean ± S.E.M.) before (pre-) and after (post-) interval sessions.

	SESSION 1		SESSION 2		SESSION 3	
	PRE-	POST-	PRE-	POST-	PRE-	POST-
S-IgA Conc. ($\mu g.ml^{-1}$)	577 (88)	608 (51)	596 (43)	569 (16)	551 (48)	622 (25)
Salivary flow ($\mu l.min^{-1}$)	361 (72)	175 (84)	263 (120)	113 (89)	204 (49)	114 (101)
S-IgA Secr. ($\mu g/min^{-1}$)	228 (79)	120 (38)	178 (62)	62 (10)	121 (33)	72 (19)

A Doubly Multivariate MANOVA showed a main effect for PRE/POST, $\lambda = 0.03$ ($F_{3,4} = 39.67$, $P<0.005$). Effect size $\eta^2 = 0.97$. Examination of the separate univariate RM ANOVAS showed that only salivary flow ($F_{1,6} = 21.89$, $P<0.005$) and S-IgA secretion rate ($F_{1,6} = 10.13$, $P<0.01$) contributed significantly to the results. No significant main effect was found for SESSION, or any significant PRE/POST×SESSION interactions ($P>0.05$).

These findings further suggest the importance of salivary flow measurements in determining the effect of exercise on S-IgA measures and highlights the potentially immunosuppressive nature of intense exercise. Normal resting values for salivary flow rates are 1-2 $ml.min^{-1}$ (Rudney, 1990, *Archives of Oral Biology*, **35**, 365-371), hence it appears resting salivary flow rates in boxers are unusually low. A trend was also emerging over time indicating further decreases in salivary flow for some boxers before sessions began. The importance of salivary flow may have implications for weight-classified sports where athletes may often train in a semi-dehydrated state when competition is approaching. Future research into S-IgA measures should not underestimate the importance of saliva as an innate immune defence in lining the mucosal surfaces as well as its effects on the acquired immune secretion of S-IgA.

THE EFFECTS OF MASSAGE ON PSYCHOLOGICAL REGENERATION FOLLOWING AMATEUR BOXING TRAINING

Both psychological regeneration and physiological recovery have been identified as key elements in the prevention of overtraining in athletes (Hooper and MacKinnon, 1995, *Sports Medicine*, **20**, 321-327). The use of massage during training by athletes is commonplace and massage has been highlighted as a modality for enhancing psychological regeneration during intense training (Shephard and Shek, 1993, *Clinical Journal of Sports Medicine,* **3**, 75-77). Despite numerous anecdotal testimonies to its efficacy, little scientific research exists on the effects of massage on psychological states, however Weinberg *et al.* (1988, *The Sport Psychologist,* **2**, 202-211) found that massage treatment led to reduced negative mood states in physical education students. The effects of massage on psychological regeneration during intensive training has not been studied, hence the aim of this study was to investigate massage and the mood response following amateur boxing training.

Royal Navy Boxing Squad members (N=9) completed a modified and shortened Profile of Mood States (POMS; McNair et al., 1971: *Manual for the Profile of Mood States*. San Diego, CA: EdITS) immediately before and after one of three 20 min. interventions following intensive afternoon training sessions. The modified POMS consisted of 21 boxing-specific items (five sub-scales of anger, vigor, tension, depression, fatigue) with internal consistencies ranging from 0.72-0.93. Boxers also rated themselves on a four item (0-7) perceived recovery scale following each intervention. The interventions were massage (M), lying resting (LR) and touching control (TC). M was applied by a qualified therapist and consisted of a standard routine encompassing the major muscle groups of the legs, back, shoulders and arms. TC consisted of contact with the same masseur, however treatment involved the application of finger pressure to a series of pseudo pressure points around the body. The period of time between interventions for each boxer was a maximum of three days, with interventions completed in a counter-balanced design.

Mood state sub-scales were analysed via a series of 3 (intervention) X 2 (pre/post) Repeated Measures ANOVA, with both independent variables as repeated measures factors, and revealed a significant interaction for the fatigue sub-scale ($F_{2,16} = 5.25$, $P<0.05$). Post hoc Tukey tests showed M Post < M Pre and M Post < LR/TC Post. This interaction superseded the main effects found in the fatigue sub-scale (M < TC/LR, $F_{2,16} = 6.00$, $P<0.05$, Post < Pre, $F_{1,8} = 20.34$, $P<0.005$). A main effect was also found for the tension sub-scale (Post < Pre , $F_{1,8} = 7.93$, $P<0.05$). No main effects or interactions were found on the mood sub-scales of vigor, depression and anger. Analysis of the additional perceived recovery scale with a one-way ANOVA, with intervention as the repeated measure, showed a significant difference (M > LR/TC, $F_{2,16} = 28.82$, $P<0.001$).

These findings suggest that massage may be an effective method of reducing perceptions of fatigue and increasing perceptions of recovery following amateur boxing training. Moreover, this study lends some scientific support for enhanced psychological regeneration following massage, which may assist in the prevention of overtraining. The finding that perceptions of fatigue and recovery differed following massage and touching control conditions suggest that some aspect of massage treatment itself may be responsible for a change in psychological status, rather than anticipation of the massage and its purported psychological benefits leading to positive mood enhancement. Further research into the physiological effects of massage in the post-training phase is warranted.

THE EFFECTS OF MASSAGE ON PSYCHOLOGICAL REGENERATION AND REPEATED AMATEUR BOXING PERFORMANCE

Massage has been shown to reduce negative mood states (Weinberg et al., 1988, *The Sport Psychologist*, **2**, 202-211). Psychological factors have been suggested to explain improved repeated performance, in the absence of physiological changes, following massage (Zelikovski et al., 1993, *British Journal of Sports Medicine*, **27**, 255-259). Little scientific evidence exists which demonstrates the efficacy of massage for promoting psychological regeneration following exercise, and research on massage effects on performance appears to be lacking (Cafarelli and Flint, 1993, *Physiotherapy in Sport*, **16**, 17-20). The aim of this study was to investigate the effect of massage on mood state following amateur boxing performance, and to examine massage effects on repeated boxing performance.

Eight amateur boxers performed two trials in a counter-balanced design, separated by a period of seven days. Subjects initially completed performance 1 (P1), which consisted of a 5 X 2 minute round, interspersed with 1 minute recovery period, simulated boxing bout. This comprised 80 punches per round, performed in a prescribed sequence from an audio cue. Punching force, measured in Newtons, was recorded from a boxing ergometer using matched 9366 force sensors (Kistler, Winterthur, Switzerland). Mean peak force was determined per round, providing a measure of boxing performance.

Immediately post P1, subjects completed a modified and shortened Profile of Mood States (POMS; McNair et al., 1971: *Manual for the Profile of Mood States*. San Diego, CA: EdITS) before and after one of two 20 min. interventions. The modified POMS consisted of 21 boxing-specific items (five sub-scales of anger, vigor, tension, depression, fatigue) with internal consistencies ranging from 0.72-0.93. Boxers also rated themselves on a four item (0-7) perceived recovery scale following each intervention. The interventions were massage (M), and no massage (NM). M was applied by a qualified therapist and consisted of a standard routine encompassing the major muscle groups of the legs, back, shoulders and arms. In NM, subjects lay resting. Following the intervention, subjects completed a second performance (P2), which was a repeated simulation of P1.

Punching force was analysed with a 2 (intervention) X 2 (performance) X 5 (round) Repeated Measures ANOVA, with all independent variables as repeated measures factors, and revealed significant main effects for performance (P1 > P2, $F_{1,7} = 7.31$, $P<0.05$) and round (R1 < R2, R3, R4, R5, $F_{4,28} = 6.38$, $P<0.001$). No significant main effects were found for intervention, or any significant interaction effects. Mood state sub-scales were analysed via a series of 2 (intervention) X 2 (pre/post) Repeated Measures ANOVA, with both independent variables as repeated measures factors, and revealed a significant interaction for the fatigue sub-scale ($F_{1,7} = 10.50$, $P<0.05$). Post hoc Tukey tests showed M Post < M Pre. No interaction effects were found on vigor, tension, fatigue and depression. Analysis of the perceived recovery scale with a Wilcoxon matched pairs test showed a significant difference between conditions (M > NM, $Z = -2.38$, $P<0.01$).

These findings suggest that massage was effective at reducing perceptions of fatigue and increasing perceptions of recovery following amateur boxing performance. However, these perceptions were not accompanied by any effects on repeated performance, which decreased in both experimental conditions. Positive perceptions of recovery may point to a potential benefit of massage, however no performance effects may question the use of massage as a performance enhancing modality.

THE EFFECTS OF MASSAGE ON PHYSIOLOGICAL RECOVERY AND SUBSEQUENT AMATEUR BOXING PERFORMANCE

INTRODUCTION

The use of massage by athletes is commonplace, and massage has been highlighted as a modality for increasing physiological recovery and sport performance (Calder 1990). Previous research on the effect of massage on blood lactate removal following intense exercise has produced equivocal results (Cafarelli and Flint 1993), and despite numerous anecdotal testimonies to its efficacy, little scientific research exists on the effects of massage on repeated sport performance. The aim of this study was to investigate the effect of massage on blood lactate removal following amateur boxing performance, and to examine massage effects on subsequent boxing performance.

METHODS

Eight amateur boxers (mean ± SD: age 23.1±2.4 yrs) performed two trials in a counter-balanced design, separated by a period of seven days. Subjects' mass was determined prior to completing performance 1 (P1), which consisted of a 5 X 2 minute round, interspersed with 1 minute recovery period, simulated boxing bout. This comprised 80 punches per round, performed in a prescribed sequence from an audio cue. Punching force, measured in N, was recorded from a boxing ergometer using matched 9366 force sensors (Kistler, Winterthur, Switzerland). Mean peak force was determined per round, providing a measure of boxing performance.

Immediately post P1, subjects undertook one of two 20 min. interventions. The interventions were massage (M), and no massage (NM). M was applied by a qualified therapist and consisted of a standard routine encompassing the major muscle groups of the legs, back, shoulders and arms. In NM, subjects lay resting. Following the intervention, subjects had a further 30 min. rest period, whereupon they completed a second performance (P2), which was a repeated simulation of P1. Heart rate (f_c) was continuously monitored by short range telemetry in both performances (Polar Sports Tester, Kemele, Finland) and fingerprick capillary blood samples were drawn to assess blood lactate concentrations (Bla) at Pre P1, Post P1, Post Intervention, Pre P2 and Post P2 (2300 StatPlus, YSI, Ohio, USA). Subjects maintained a normal diet throughout the experiment period, and refrained from intensive training.

RESULTS

No differences were found between conditions in Pre P1 body mass (M 78.1±8.1 kg vs NM 78.2±9.1 kg, $p>0.05$). Punching force, blood lactate and heart rate were analysed with appropriate Repeated Measures ANOVA, and revealed no differences between conditions for P1. Similarly, no differences were found in blood lactate following massage or rest interventions (Bla: M 1.87±0.1 mM vs NM 2.19±0.26 mM). During P2, no differences were found in punching force (M 1239±30 N vs NM 1213±27 N) or heart rates (f_c: M 180±4 $b.min^{-1}$ vs NM 179±5 $b.min^{-1}$). Post P2 blood lactate showed a significant difference (Bla: M 5.39±0.35 mM vs NM 4.52±0.37 mM). However, punching force in P2 was lower than P1 in both experimental conditions (M 2%, NM 1.8% decreases, $p<0.05$).

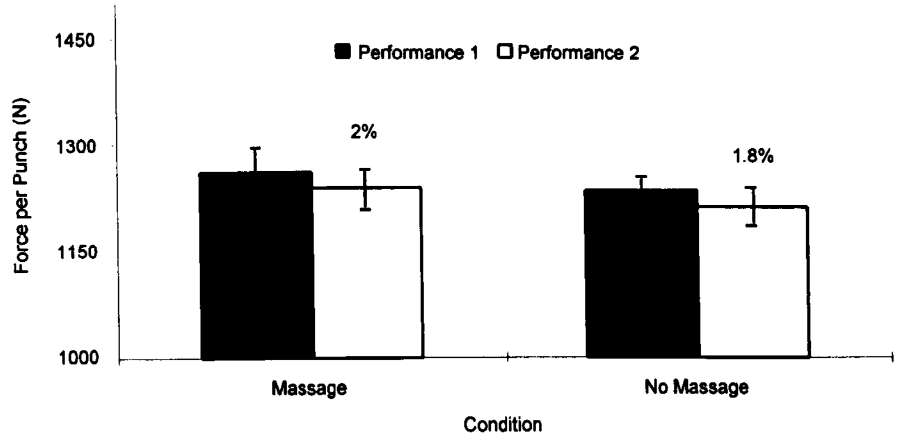

Figure 1 showing mean(±SD) decreases in performance 2 punching force in massage and no massage conditions ($p<0.05$). No differences were found in punching force between conditions ($p>0.05$).

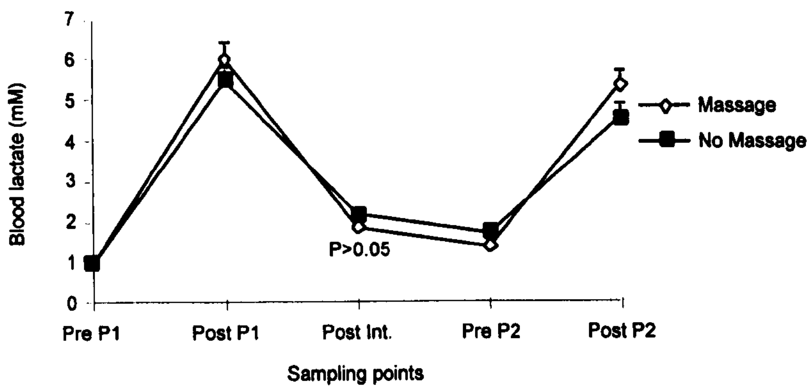

Figure 2 showing mean(±SD) blood lactate concentrations in massage and no massage conditions pre and post boxing performances and post intervention.

DISCUSSION

These findings suggest that massage was no more effective than passive rest at reducing levels of blood lactate following amateur boxing performance. Additionally, subsequent performance decreased in both experimental conditions. In conclusion, the lack of change in physiological markers and performance may question the use of massage as a performance enhancing modality.

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Appendix 4

ANOVA/MANOVA TABLES

Experiment 1

One-Way RM ANOVA for effect of time (mood states)

Anger

	SS	DF	MS	F	p.
Within	76.75	21	3.65		
Time	140.25	3	46.75	12.79	< .001

Tension

	SS	DF	MS	F	p.
Within	86.91	21	4.14		
Time	375.34	3	125.11	30.23	< .001

Vigor

	SS	DF	MS	F	p.
Within	98.25	21	4.68		
Time	688.25	3	229.42	49.04	< .001

Fatigue

	SS	DF	MS	F	p.
Within	89.88	21	4.28		
Time	662.13	3	220.71	51.57	< .001

Confusion

	SS	DF	MS	F	p.
Within	147.66	21	7.03		
Time	21.09	3	7.03	1.00	.42

Depression

	SS	DF	MS	F	p.
Within	196.66	21	9.36		
Time	20.59	3	6.86	0.73	.54

Experiment 3a

One-Way RM ANOVA for effect of time (mood states)

Anger

	SS	DF	MS	F	p.
Within	35.00	14	2.5		
Time	32.33	2	16.17	6.47	.01

Tension

	SS	DF	MS	F	p.
Within	57.58	14	4.11		
Time	53.08	2	26.54	6.45	.01

Vigor

	SS	DF	MS	F	p.
Within	20.25	14	1.45		
Time	239.08	2	119.54	82.65	<.001

Fatigue

	SS	DF	MS	F	p.
Within	86.92	14	6.21		
Time	307.75	2	153.88	24.79	<.001

Depression

	SS	DF	MS	F	p.
Within	116	14	8.29		
Time	9.33	2	4.67	.56	.58

One-way RM MANOVA for effect of time (S-IgA)

Wilksλ	DF	F	p.
0.34	2,6	.63	.71

Univariate one-way RM ANOVAs

	SS	SS	MS	MS	F	p.
Conc.	13132	321921	6566	22994	.28	.76
Flow	.008	.08	.004	.005	.68	.52
Secr.	30903	144048	15451	10289	1.5	.26

Experiment 3b

One-Way RM ANOVA for effect of time (saliva flow)

	SS	DF	MS	F	p.
Within	.19	14	.01		
Time	.03	2	.02	1.14	.35

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Experiment 4

Session x PrePost DM MANOVA (S-IgA)

Session

Wilksλ	DF	F	p.
.17	1,6	.771	.70

PrePost

Wilksλ	DF	F	p.
.03	3,4	39.67	.002

Session x PrePost

Wilksλ	DF	F	p.
.175	1,6	.781	.69

Univariate one-way RM ANOVAs

Session

	SS	SS	MS	MS	F	p.
Conc.	744	776288	372	64690	.005	.98
Flow	88686	141265	44343	11772	3.76	.09
Secr.	44322	176285	22161	14690	1.5	.26

PrePost

	SS	SS	MS	MS	F	p.
Conc.	6530	174410	6530	29068	.22	.65
Flow	211651	58010	211651	9668	21.89	.003
Secr.	87390	51716	87390	8619	10.13	.01

Session x Prepost

	SS	SS	MS	MS	F	p.
Conc.	16605	306628	8302	25552	.32	.72
Flow	16134	26727	8067	2227	3.62	.08
Secr.	9184	83702	4592	6975	.65	.53

Experiment 5

Condition x PrePost RM ANOVA (mood states)

Anger

Condition

	SS	DF	MS	F	p.
Within	46.3	16	2.89		
Condition	8.04	2	4.02	1.39	.28

PrePost

	SS	DF	MS	F	p.
Within	13.26	8	1.66		
PrePost	4.74	1	4.74	2.86	.13

Condition x PrePost

	SS	DF	MS	F	p.
Within	10.52	16	.66		
Cond. x PrePost	.48	2	.24	.37	.69

Fatigue

Condition

	SS	DF	MS	F	p.
Within	68.96	16	4.31		
Condition	51.7	2	25.85	6.0	.01

PrePost

	SS	DF	MS	F	p.
Within	23.67	8	2.96		
PrePost	60.17	1	60.17	20.34	.002

Condition x PrePost

	SS	DF	MS	F	p.
Within	42.67	16	2.67		
Cond. x PrePost	28	2	14	5.25	.01

Tension

Condition

	SS	DF	MS	F	p.
Within	71	16	4.44		
Condition	10.33	2	5.17	1.16	.34

PrePost

	SS	DF	MS	F	p.
Within	20.33	8	2.54		
PrePost	20.17	1	20.17	7.93	.02

Condition x PrePost

	SS	DF	MS	F	p.
Within	13.22	16	.83		
Cond. x PrePost	4.78	2	2.39	2.89	.08

Vigor

Condition

	SS	DF	MS	F	p.
Within	49.52	16	3.09		
Condition	1.81	2	.91	.29	.75

PrePost

	SS	DF	MS	F	p.
Within	27.37	8	3.42		
PrePost	9.8	1	9.8	2.86	.13

Condition x PrePost

	SS	DF	MS	F	p.
Within	10.63	16	.66		
Cond. x PrePost	2.7	2	1.35	2.03	.17

Depression

Condition

	SS	DF	MS	F	p.
Within	23.56	16	1.47		
Condition	5.78	2	2.89	1.96	.18

PrePost

	SS	DF	MS	F	p.
Within	1.33	8	17		
PrePost	.67	1	.67	4.0	.09

Condition x PrePost

	SS	DF	MS	F	p.
Within	3.56	16	.22		
Cond. x PrePost	.44	2	.22	1.00	.39

One-Way RM ANOVA for effect of condition (perceived recovery)

	SS	DF	MS	F	p.
Within	130.81	16	8.18		
Condition	471.18	2	235.58	28.82	< .001

Condition x PrePost RM ANOVA (saliva flow)

Condition

	SS	DF	MS	F	p.
Within	.80	16	.05		
Condition	.01	2	.00	.05	.90

PrePost

	SS	DF	MS	F	p.
Within	.04	8	.00		
PrePost	.03	1	.03	6.63	.03

Condition x PrePost

	SS	DF	MS	F	p.
Within	.09	.16	.01		
Cond. x PrePost	.02	2	.01	2.28	.15

Experiment 6

Condition x PrePost RM ANOVA (mood states)

Anger

Condition

	SS	DF	MS	F	p.
Within	30.72	7	4.39		
Condition	.03	1	.03	.01	.93

PrePost

	SS	DF	MS	F	p.
Within	39.22	7	5.6		
PrePost	16.53	1	16.53	2.95	.13

Condition x PrePost

	SS	DF	MS	F	p.
Within	1.72	7	.25		
Cond. x PrePost	.03	1	.03	.13	.73

Fatigue

Condition

	SS	DF	MS	F	p.
Within	21.88	7	3.13		
Condition	21.13	1	21.13	6.76	.03

PrePost

	SS	DF	MS	F	p.
Within	35	7	5		
PrePost	242	1	242	48.4	< .001

Condition x PrePost

	SS	DF	MS	F	p.
Within	12	7	1.71		
Cond. x PrePost	18	1	18	10.5	.01

Tension

Condition

	SS	DF	MS	F	p.
Within	11	7	1.57		
Condition	8	1	8	5.09	.07

PrePost

	SS	DF	MS	F	p.
Within	19.5	7	2.79		
PrePost	40.5	1	40.5	14.54	.007

Condition x PrePost

	SS	DF	MS	F	p.
Within	27.88	7	3.98		
Cond. x PrePost	1.13	1	1.13	.28	.61

Vigor

Condition

	SS	DF	MS	F	p.
Within	14.97	7	2.14		
Condition	13.78	1	13.78	6.44	.03

PrePost

	SS	DF	MS	F	p.
Within	24.22	7	3.46		
PrePost	19.53	1	19.53	5.65	.05

Condition x PrePost

	SS	DF	MS	F	p.
Within	27.72	7	3.96		
Cond. x PrePost	9.03	1	9.03	2.28	.18

Depression

Condition

	SS	DF	MS	F	p.
Within	19	7	2.71		
Condition	.50	1	.50	0.18	.68

PrePost

	SS	DF	MS	F	p.
Within	11.38	7	1.63		
PrePost	.13	1	.13	.08	.79

Condition x PrePost

	SS	DF	MS	F	p.
Within	5.38	7	.77		
Cond. x PrePost	1.13	1	1.13	1.47	.27

Condition x Performance x Round RM ANOVA (punching force)

Condition

	SS	DF	MS	F	p.
Within	662995	7	94707		
Condition	29741	1	29741	.31	.60

Performance

	SS	DF	MS	F	p.
Within	22727	7	3246		
Perf	23723	1	23723	7.31	.03

Round

	SS	DF	MS	F	p.
Within	74078	28	2645		
Round	67553	4	16888	6.38	.001

Condition x Performance

	SS	DF	MS	F	p.
Within	31563	7	4509		
Cond. x Perf	148.46	1	148.46	.03	.86

Condition x Round

	SS	DF	MS	F	p.
Within	39338	28	1404		
Cond. x Round	9766	4	2441	1.74	.17

Performance x Round

	SS	DF	MS	F	p.
Within	31593	28	1128		
Perf x Round	20699	4	5174	4.59	.006

Condition x Performance x Round

	SS	DF	MS	F	p.
Within	38711	28	1382		
Cond. x Perf x Round	8211	4	2053	1.48	.23

Condition x Performance x Round RM ANOVA (heart rates)

Condition

	SS	DF	MS	F	p.
Within	1023	7	146.19		
Condition	58.81	1	58.81	0.4	.55

Performance

	SS	DF	MS	F	p.
Within	303.24	7	43.32		
Perf	178.51	1	178.51	4.12	.08

Round

	SS	DF	MS	F	p.
Within	465.51	28	16.63		
Round	2949	4	737.27	44.35	< .001

Condition x Performance

	SS	DF	MS	F	p.
Within	158.94	7	22.71		
Cond. x Perf	41.04	1	41.04	1.81	.22

Condition x Round

	SS	DF	MS	F	p.
Within	113.44	28	4.05		
Cond. x Round	41.16	4	10.29	2.54	.07

Performance x Round

	SS	DF	MS	F	p.
Within	148.54	28	5.3		
Perf x Round	11.46	4	2.87	0.54	.70

Condition x Performance x Round

	SS	DF	MS	F	p.
Within	159.96	28	5.71		
Cond. x Perf x Round	40.84	4	10.21	1.79	.17

Condition x Time DM MANOVA (lactate and glucose)

Condition

Wilksλ	DF	F	p.
.87	2,6	.418	.67

Time

Wilksλ	DF	F	p.
.04	8,54	25.52	< .001

Condition x Time

Wilksλ	DF	F	p.
.41	8,54	3.72	.002

Univariate RM ANOVAs

Condition

	SS	SS	MS	MS	F	p.
Lactate	.372	2.85	.372	.408	.910	.37
Glucose	.025	4.83	.025	.690	.037	.85

Time

	SS	SS	MS	MS	F	p.
Lactate	294.2	17.71	73.55	.632	116.22	< .001
Glucose	14.67	19.39	3.66	.692	5.29	.003

Condition x Time

	SS	SS	MS	MS	F	p.
Lactate	4.34	5.35	1.08	.191	5.68	.002
Glucose	2.62	6.56	.655	.234	2.79	.05