MENTAL TRAINING FOR ENDURANCE SPORTS

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Abstract

The effects of a cognitive behavioral mental training intervention on endurance performance were explored using a time lagged multiple baseline single subject design. Seven local and provincial level endurance athletes were educated on goal setting, imagery, relaxation, and self-talk. The two dependent variables used to explore the effects of the intervention were perceived mental skills, assessed by a questionnaire, and power output at ventilatory threshold, a physiological-based performance measure. Training load, volume, frequency, and intensity were monitored during the length of the study and were kept constant. Results demonstrated that a short-term cognitive-behavioral intervention enhanced participants' self-evaluation in a number of mental skills. Power output at Ventilatory Threshold (VT) did not demonstrate significant changes after the intervention, showing no physiological adaptations as a consequence of the intervention. Two other studies using similar interventions found a consistent field performance enhancement effect on gym triathlon performance and 1600 metres running times (Patrick & Hrycaiko, 1998; Thelwell & Greenless, 2001). Because physiological adaptations were not found in this study, the possible sources of the field performance enhancement effect found in other investigations are discussed. Social validation scales indicated positive effects of the intervention on the participants' satisfaction, importance, and usefulness of the intervention, and significance of the perceived changes in the performance. Qualitative data also support the participants' perceived usefulness and satisfaction with the outcome of the study.

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Introduction

When elite athletes are compared to recreational athletes or non-participants, one would expect to discover large differences in certain physical skills. However, the general public does not seem to understand that elite athletes also differ from others in the use of certain mental skills (De Francesco & Burke, 1997; Gould & Eklund, 1991; Gould, Weiss, & Weinberg, 1981; Greenspan & Feltz, 1989; Hamilton & Fremouw, 1985; Heyman, 1984,1987; Mahoney & Avener,1977; Mahoney & Gabriel, 1987; Meyers, Bourgeois, LeUnes, & Murray, 1998; Meyers, LeUnes, & Bourgueois, 1996; Orlick, 1986; Orlick & Partington, 1989; Owen & Lee, 1987; Weinberg & Gould, 1999). It seems that the most successful athletes already use psychological methods to prepare themselves for performance. However, the assistance of a sport psychologist may accelerate and enhance the quality of the learning process (Hardy & Jones, 1994).

In the last decade, numerous studies have conclusively suggested that psychological skills training enhances performance in various sports (Gould & Eklund, 1991; Gravel, Lemioux, & Ladouceur, 1980; Greenspan & Feltz, 1989; Hamilton & Fremouw, 1985; Hardy & Jones, 1994; Heyman, 1987; Lerner, Ostrow, Yura, & Etzel, 1996; McDougall, Scott, McFarlane, Leblanc, & Cormier, 2000; Orlick, 1986; Orlick & Partington, 1989; Vealy, 1994; Weinberg & Gould, 1999). Most of these interventions are based on the cognitive-behavioural model. This psychotherapy derived model blends two branches of learning in psychology; the behavioural and the cognitive. This model, which asserts that emotion and behaviour are both influenced by cognitions (Hollon & Kendall,1979), promotes change through systematic implementation of certain cognitive and behavioural techniques. With the inclusion of new methods, such as skills training, self-instruction training, stress inoculation training, and coping skills techniques, the cognitive-behavioural model began to adopt an educational approach (Golfried, 1979; Meichembaum, 1977).

It is necessary to understand the distinction, introduced by Vealy (1988), between methods and skills, as these terms are sometimes erroneously used in sport psychology. Methods refer to the procedures and techniques borrowed from psychology's cognitive-behavioural theory, such as relaxation training, imagery practice, and positive self-talk techniques. Skills, on the other hand, are the desired mental abilities or qualities that would facilitate performance. Examples of such skills are arousal control, attentional focus, self-confidence, anxiety control, commitment, concentration ability, mental readiness, self-awareness, motivation, coping with adversity, and self-efficacy, among others. These skills are usually self rated by the individual. Several studies have pointed out that both coaches and athletes have referred to these skills as facilitative of performance (Hardy, Jones, & Gould, 1996; Kirschenbaum, 1985; Scott, Scott, Bedic, & Dowd, 1999). Methods are used to develop skills or to attain certain qualities.

From the sport psychology view, there are no such thing as therapeutic goals. Nevertheless, cognitive-behavioural methods or techniques are used to teach a number of skills and cognitive strategies to facilitate performance before, during, and after practice (Gordon, 1990; Gould, Petlichkoff, Hodge, & Simons 1990; Hardy, Jones, & Gould, 1996; Prapavessis, Gordon, & Grove, 1990). During this educational process, the athlete learns the importance of mental training, how mental skills affect the execution of the physical skills, and how to invoke a number of cognitive and behavioural techniques (Desiderato & Miller, 1979; Seabourne, Weinberg, & Suinn, 1985; Silva, 1982). Psychological skill training programs are based on the premise that "athletes are basically mentally healthy but they may need to learn cognitive skills and strategies to cope with the demands" (Vealy, 1988, p.495).

The intervention goal is to promote and increase the usage of mental skills by the athlete. The skills promoted and monitored in this intervention have been anxiety and worry management, self-confidence, mental preparation, imagery ability, concentration ability, motivation, and relaxation ability. In mastering these mental skills, the athlete would be able to cope with the high physical and psychological demands imposed by the arduous sports environment which, ultimately, should lead to an increase in performance. An automatic use of the proposed methods should lead to the desired behavioural change. Additionally, abilities learned during the process would be applicable to any other setting. The athletes would be told how the training consists of life skills, so their participation could provide many benefits for them.

After Eynsenck's (1952) works strongly reproved the efficacy of psychotherapy, a growing interest in thoughtful evaluative research appeared in the psychotherapy field. Eynsenck's research clarified the effectiveness of psychotherapy (Dobson & Khatri, 2000; Leahy & Holland, 2001). Today, sport psychology interventions for performance enhancement are in the same state as clinical psychotherapy was 50 years ago. Therefore, evaluative research is needed for sport psychology interventions to demonstrate their efficacy and effectiveness (De Francesco & Cronin, 1988; Hardy & Jones, 1994; Vealy, 1988, 1994). In order for the sport psychology profession to be taken seriously, the "effectiveness of the interventions and procedures needs to be convincingly demonstrated" (Grove, Norton, Raalte, & Brewer, 1999, p. 107). Sport psychology as a professional field is still in its formative stages, so it is necessary to demonstrate credibility and accountability (Bryan, 1987; Grove et al., 1999; Hanson & Newburg, 1992; Heyman, 1987). Owen and Lee (1987) warned the sport psychology research community of the dangers of using naive inference to evaluate interventions. Serious research processes need to be implemented in real practice situations without neglecting the efficacy of the research findings (Vealy, 1988). Therefore, field implementations, such as the one completed in this study, have been recommended in the spirit of demonstrating efficacy (Hardy & Jones, 1994; Holm, Beckwith, Ehde, & Tinius, 1996; Patrick & Hrycaiko, 1998).

The evaluation of psychological skills training programs has been focussed in non-endurance sports such as basketball (Hall & Erffmeyer, 1983; Hamilton & Fremouw, 1985; Kendall, Hrycaiko, Martin, & Kendall, 1990), tennis (Noel, 1980), karate (Weinberg, Seabourne, & Jackson, 1981), boxing (Heyman, 1987), and golf (Kirschenbaum & Bale, 1979). Certainly, a lack of evaluation for endurance sport interventions exists (Patrick & Hrycaiko, 1998; Thelwell & Greenless, 2001). The relevance of mental skills in endurance sport was clearly presented by Scott et al. (1999) in their study assessing endurance performance under different cognitive conditions. Three cognitive strategies to be used while completing a 40-minute rowing ergometer task were associative thinking, dissociative-video, and dissociative-music. The greatest gains in performance were found in the associative condition, illustrating the importance of using mental skills.

Endurance is the ability to sustain or repeat intense effort for a prolonged period of time. During these long periods of time, performance relies on the aerobic system for energy supply (Wilmore, 1994). Sports such as the triathlon, marathon, swimming, long distance running, road cycling, and cross-country skiing are categorized as endurance sports because they involve major use of the aerobic system. From a physiological perspective, performance enhancement in endurance sport is defined by adaptations at two different levels; peripheral and central (McArdle, Katch, & Katch, 1991). Central adaptations, such as heart size, stroke volume, heart rate changes, blood parameters, and cardiac output, are cardiorespiratory (Hollozky & Coyle, 1984). Several adaptations occur as well at the muscle level, such as changes in fiber type, capillary supply, myoglobin content, and in the oxidative enzymes.

First attempts to evaluate the effectiveness of mental training in endurance sports were done by Richard Suinn with cross- country skiers (Suinn, 1972,1977). The intervention included relaxation, imagery, and thought stopping during competitions. The author reported better competition performance by the treatment group. Endless methodological flaws can be found in Suinn's works, so the results should be taken as anecdotal. Later in the 1980s, Gravel et al. (1980) were pioneers in the introduction of control group design in the assessment of the effectiveness of implementations for endurance activities. Using 12 experimental subjects in the design, the researchers concluded that participants changed their negative ruminations towards a more adaptive competitive behaviour and as a result performance increased. During the 1980s, several studies focussed on discovering the mental skills employed by successful performers. Studies carried out mostly with runners set a starting point for the mental skills training approach in endurance sports (Schomer, 1986; Ungerleider, Golding, Porter, & Foster, 1989).

Scott et al. (1999), with a sample of 9 varsity rowers using a single-subject design, found that certain mental coping strategies were beneficial for performance. Therefore, the assumption was strengthened that the use of different mental skills by athletes would affect endurance performance. Patrick and Hrycaiko (1998), also using a single-subject design, illustrated how a short-term cognitive-behavioural intervention using training in goal setting, imagery, relaxation, and self-talk improved both the usage of mental skills and the participants' times in a 1600-metre run. The implementation included three ninety-minute sessions plus additional homework assignments. Pre- and post-intervention usage of mental skills was monitored using a mental skills assessment questionnaire, which assessed relaxation ability, imagery ability, self-talk usage, goal setting, and general mental skills usage (Patrick & Hrycaiko, 1998). This research overcame methodological flaws by using manipulation checks, thus assuring the internal validity of the implementation. Procedural reliability was monitored using implementation protocols (Hrycaiko & Martin, 1996). The main dependent variable, time to complete a 1600-metre run, provided external validity. However, the research lacked control over the training of the participants during the process. Thus, reductions in the times could be due to other variables such as changes in the volume or intensity of physical training.

Recently, Thelwell and Greenless (2001) assessing gymnasium triathlon performance, illustrated how all five participants in a single-subject design notably enhanced their usage of mental skills after five sessions of cognitive-behavioural intervention. To evaluate the use of mental skills, Thelwell and Greenless (2001) employed the same self-report tool as Patrick and Hrycaiko (1998). In both studies, individualized logbooks completed daily by the participants served a double function: monitoring mental skills usage and providing manipulation checks. This double function of the logbooks resulted in the overlapping of skills usage and techniques used to develop the skills. Therefore, in the implementation for the current study, the daily logbooks were used only as manipulation checks. A separate questionnaire was used to assess the usage of mental skills by the participants. The mental skills evaluated by this questionnaire include imagery ability, mental preparation, self-confidence, anxiety and worry management, concentration ability, relaxation ability, and motivation (Bull, Albinson, & Shambrook,1996) (see Appendix A). The usage of these particular mental skills was evaluated to form the baseline and the post-intervention. Moreover, visual analysis of the scores during these two phases indicated possible changes due to the intervention.

Thelwell and Greenless (2001) applied the same techniques (goal setting, relaxation, imagery, and self-talk) and implementation protocols as Patrick and Hrycaiko (1998) also using a single-subject design. In the Thelwell and Greenless study, the major dependent variable was ergometer performance time to complete a gymnasium endurance task. Participants were local club level athletes. The effect of social comparison effects due to the gymnasium environment might have played a role in the participant's performance. In this study, audience effect was not controlled which could influence the research replicability in a different environment.

In the current study, physiological adaptations were monitored together with the mental skills usage to evaluate whether the increases in the outcome endurance performance that were demonstrated in other studies (Patrick & Hrycaiko, 1998; Thelwell and Greenless, 2001), are also related to adaptations in the underlying physiology. The physiological index of endurance accounting for adaptations and performance changes was power output at ventilatory anaerobic threshold (Farrel, Wilmore, & Coyle, 1979; Kumagai et al., 1995; Powers, Dodd, Deadson, Byrds, & McKnight, 1983; Sjodin & Jacobson, 1981). Anaerobic threshold represents a physiological demarcation point indicating a change in the source of energy during incremental physical exercise. This key point is related to changes in several physiological parameters. In this case, the gases consumed and produced by the participant during the increasing workload task indicated the exact point for the anaerobic threshold. Participants completed an incremental workload protocol. The watts produced at this particular physiological moment were recorded, forming the power output at anaerobic threshold. An excellent characteristic of the measurement of power output at ventilatory anaerobic threshold, apart from being simply a performance measure, is that it provides information about possible adaptations occurring both in the periphery and in the body as a whole. The performance gains established in the literature on field measurements, 1600-metre running times, and triathlon gymnasium tasks should also be reflected in the physiological indexes.

Patrick and Hrycaiko (1998) and Thelwell and Greenless (2001), using social validation scales, found acceptance and agreement by the participants about the goals of the implementation, assuring the social relevance of the interventions. Social validity refers to the participants' perceptions of three different elements of the intervention: the goals of the treatment, the treatment procedures, and the outcomes of the treatment procedures. The necessity of including social validation scales with the interventions has been repeatedly documented for cognitive-behavioral interventions in general (Foster & Mash, 1999; Martin & Hrycaiko, 1983), but also in the sport setting (Hume, Martin, Gonzalez, Cracklen, & Genthon, 1985; Scott et al., 1999; Shambrook & Bull, 1996) where it has been defined as an evaluation of the performance changes (Scott et al.,1999).

The reasons for using goal setting, relaxation, imagery, and self-talk are supported by studies reviewing the importance of their combined effects (Burton, 1990; Greenspan & Feltz, 1989; Hardy, Gammage, & Hall, 2001; Weinberg, Chan, & Jackson, 1983). For example, relaxation has been presented as facilitative of imagery (Sherman & Poczwardowski, 2000), and self-talk, as facilitative of relaxation (Kendall et al., 1990). Goal setting, including physical and mental goals, can also help the implementation of the other techniques (Hogg, 2000). Their combined utilization is also justified by the cognitive-behavioural model which supports the double line of action between behavioural and cognitive skills (Beck & Emery, 1985). Anxiety management can be enhanced by both cognitive and behavioural techniques such as imagery (Jones & Johnson, 1980), relaxation (Meyers et al.,1998), self-talk (Rushall, 1992), or even goal setting (Hardy et al., 1996). Other techniques such as hypnosis or other forms of mediation and self-control could be included; however, they do not follow the cognitive-behavioural model assumptions or do not possess enough scientific support in this context.

Purpose of Study

The primary purpose of this study was to evaluate the effects of a short-term cognitive-behavioural implementation on a number of reported mental skills by endurance athletes, following the outlines presented by Patrick and Hrycaiko (1998) and Thelwell and Greenless (2001). Experimental and therapeutic criteria were reviewed.

A secondary purpose was to determine whether endurance performance improvements previously demonstrated in the literature (Patrick & Hrycaiko, 1998; Thelwell & Greenless, 2001), caused by a short-term cognitive-behavioural intervention, are also reflected in a physiological endurance performance index as power output at ventilatory anaerobic threshold. Power output at ventilatory threshold has been proposed as the most sensible objective physiological assessment of endurance performance adaptations (Daniels, Yarbourgh, & Foster, 1978; Foster et al., 1982).

Finally, the study evaluated the intervention in terms of social validation. Social validation assessed participants' reactions to treatment procedures and experimental outcomes (Foster & Mash, 1999; Kazdin, 1982; Kendal et al., 1990).

Method

Design

For the purposes of this study, a single-subject design was used. During the last decade, this methodology has been repeatedly proposed as an inquiry method suitable for sport psychology interventions (Bryan, 1987; Hrycaiko & Martin, 1996; McDougall et al., 2000; Tennenbaum & Bar-Elli, 1992; Wollman, 1986). For this kind of intervention, several repeated measures of the athlete provide relevant information about changes in a determined variable. Single-subject design does not look for average performances of groups.

The design selected for this study is a multiple-baseline across participants. This has also been labelled as a "time-lagged control" design (Hersen & Barlow, 1976, p.229). All the participants were repeatedly tested, setting up a multiple baseline. When the multiple-baseline was stable, the intervention was introduced to only one of the participants. The use of mental skills and the power output at the ventilatory anaerobic threshold of this first participant was expected to change due to the mental training intervention, while the other participants were not expected to change. Therefore, they acted as controls for the first participant. Only when responses were stabilized for all participants was the intervention introduced to the next participant and so on successively (Jones, 1978; Kazdin, 1982; Krishef, 1991). The design is illustrated in Figure 1.

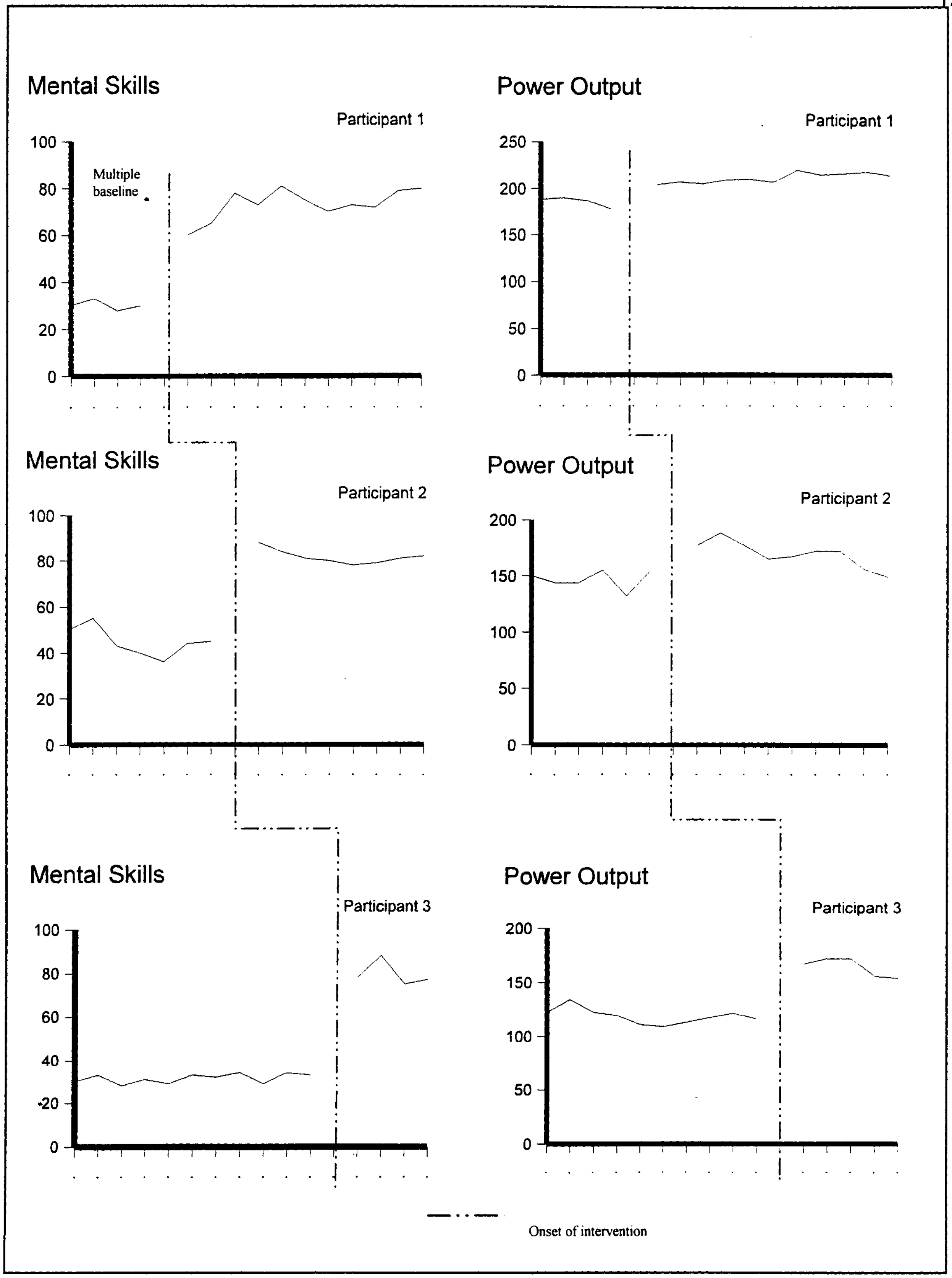

Figure 1. Research Design

Using a multiple baseline single-subject design presents several advantages. The non sampling-based nature of single-subject design makes it particularly suitable for a setting in which samples are rarely randomly selected or tested for normalcy of the populations (Hrycaiko & Martin, 1996). This design allows for an ongoing assessment of the athletic performance while being, at the same time, sensitive to small changes in the dependent variable. Relatively small changes in dependent variables are a common feature when working with athletes (Shambrook & Bull, 1996). Changes in the performance can be minimal, particularly when studying elite or world class elite athletes. Averaging data within groups can lead to ignoring the impact of the intervention on a particular individual (Bryan, 1987; Diekhoff, 1992; Zaichkowsky, 1980). The individual monitoring allows for unexpected results, which are particularly common in the sport setting. Also, with a single-subject design, every participant receives the performance enhancement treatment. Therefore, athletes and coaches are more easily convinced to take part in the research. Another particular feature of multiple baseline single-subject design is that participants do not need to withdraw the treatment to show performance change (Hersen & Barlow, 1976).

This kind of design is based on a replication logic, as compared to the sampling logic used for group designs (Hrycaiko & Martin, 1996; Smith,1988). This is an advantage for studying the sport setting because no assumptions about the population need to be made. In single-subject design, the prediction is achieved by projecting or extrapolating into the future, a continuation of the baseline performance (Kazdin, 1982).

The dependent variables, usage of mental skills and power output at VAT, were assessed as many times as required to establish a stable multiple baseline across participants. The baseline assessment serves two functions; a descriptive function of the physical performance of the individual and a predictive function, which refers to the level of performance for the particular variable if the intervention were not provided. The aim is to introduce an intervention in order to evaluate changes in the dependent measures. A stable rate or a trend in the direction opposite to that predicted for the effects of the treatment, defines the baseline. At this point, the intervention can be introduced. The absence of a trend provides a clear basis to predict no future changes in performance with no intervention. Initially, usage of mental skills (see Appendix A) and the power output at VAT were measured to establish the baseline, after the first intervention they were measured once a week, during twelve weeks.

Procedure

The intervention consisted of a brief cognitive-behavioural intervention which included the following techniques: goal setting, relaxation training, imagery training, and self-talk control. These types of techniques are usually taught using 12 to 15 sessions (Weinberg & Gould, 1999); however, in this particular design, the intervention was presented to each participant in four sessions during a one week period. In single-subject design, rapid and observable changes from the baseline, demonstrate the efficacy of the intervention. This is the main reason for using a short intervention of four sessions over seven days (Patrick & Hrycaiko, 1998; Smith, 1988; Thelwell & Greenless, 2001). The quicker the changes appear in the dependent variables after introducing the intervention, the more likely those changes can be attributed to the intervention (Kazdin, 1982). The total length of the study was 12 weeks. The first week was dedicated to the assessment of the multiple baseline, using the physical test and the mental skills questionnaire (see Appendix A). When the dependent variables became stable in all participants, the intervention was introduced for a week to the first participant.

Interventions were implemented one at a time for the remaining participants and proceeded as follows. In the first session, the rationale for the use of the intervention and the cognitive-behavioural model were provided and goal setting techniques were introduced (see Appendix D). Also, in this session, the participant was introduced to the daily use of the intervention logbook (see Appendix B), which acted as a manipulation check to monitor the intervention effects. In the second session, the goal setting process was reviewed and training in relaxation with its rationale was provided. A relaxation session was completed and the participants received a standardized tape with progressive muscular relaxation instructions, as described by Jacobson (1930), to be used at home. Relaxation sessions were be prescribed as part of the self training and were introduced in the goal setting program as mental goals (see Appendix B). In the third session, the progress on both goal setting and relaxation training was discussed, and imagery, with its rationale, was introduced. The value of practising internal and external imagery was presented. Following a relaxation session, the participant was introduced to some simple imagery exercises. Also, a video entitled "*What you see is what you get*" was given to the participants to watch (Coaching Association Canada, 1987). Through the video, the participants were introduced to some scientific evidence and some examples of Olympic athletes promoting the use of mental training. In the fourth session, the previous techniques were reviewed and self-talk was introduced. The participants were asked to complete several homework tasks, such as readings or self-help assignments. For example, they were asked to complete a self-awareness record sheet (see Appendix C), watch the imagery video, and complete the goals sheet (see Appendix D). Apart from being an integral part of a cognitive-behavioural intervention, homework is positively correlated to therapy outcome in cognitive-behavioural therapy (Beck, 1995; Kazantzis, Deane & Ronan, 2000).

The presentation of a sound rationale for the use of each technique has been proposed as a relevant way to enhance the treatment adherence, so some intervention time was devoted to this (Beck, 1995). Also, at the end of every session, time was provided to receive feedback from the participants and to assure that the techniques were clearly understood. At the end of the fourth session, the participants were read and given a message (see Appendix E) similar to that used by Patrick and Hrycaiko (1998) to raise awareness about the potential of the learned techniques and to encourage their use.

In order to conclude that the intervention of the mental training program was the only reason for the changes to the dependent variables, other variables potentially affecting the dependent measurements needed to be controlled. The literature in endurance physiology was reviewed to identify all of the possible items affecting the performance variable of power output at the ventilatory threshold. The most important variables affecting the training adaptations are training volume, sessions frequency, and session intensity (Bompa, 1999). Intensity was monitored using Borg's Rate of Perceived Exertion Scale (Borg, 1982) (see Appendix F). Borg's scale (1982) provides an accurate index of the intensity in endurance tasks (Huang, 1998; Lamb, Estons, &

Corns, 1999; Moyna et al., 2001; Robertson, Goss, & Meltz, 1998). The number of hours of training per week, the number of training sessions, and the rating of perceived exertion was monitored using the personal logbooks during the baseline (Appendix F). The three extraneous variables affecting the performance measure (volume, frequency, and intensity), were monitored daily by asking the participants to complete the baseline diary (see Appendix F). During and after the intervention, the exercise regimes were prescribed for the rest of the time of the study in order to keep intensity, volume and frequency equal during the baseline, intervention, and follow up phases. During the post-intervention, the completion of the prescribed physical training was individually monitored weekly during the physical testing, using the intervention diary (see Appendix B). This research is innovative controlling for the frequency, volume and intensity of the physical training. No other research investigating the topic has controlled this major threat to the internal validity.

Each intervention session followed a strict protocol (see Appendix G). The completion of the protocol was assured by checklists (Smith, 1988; Tennenbaum & Bar-Elli,1992). A major concern that has been reported recently in the literature involving single-subject design is the treatment integrity (Kazdin, Hersen, & Bellack,1983). This refers to "the accuracy and consistency with which independent variables are implemented" (Franklin, Allison, & Gorman, 1993, p. 93).The use of manipulation checks included in the participants' intervention diaries (see Appendix B) provided greater confidence in treatment effects and support for internal validity. Manipulation checks during and after the intervention "assess the degree to which subjects were affected by each component of the intervention" (Greenspan & Feltz, 1989, p. 232). This type of logbook has been used successfully in similar experimental situations (Patrick & Hrycaiko, 1998; Wanlin, Hrycaiko, Martin, & Mahon, 1997). Standardized intervention of the mental training program and the use of intervention check lists by the researcher and an observer would facilitate greater precision, consistency, and it would encourage confirmatory research. Figure 2 presents the tasks to be completed by a single participant during the length of the study.

Participant - 1 -	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Week 1	Logbook1 Physical Mental	Logbook1	Logbook1 Physical Mental	Logbook1	Logbook1 Physical Mental	Logbook1	Logbook1
Week 2	Logbook2 Interventio n	Logbook2 Intervention	Logbook2 Intervention	Logbook2 Intervention	Logbook2	Logbook2 Physical Mental	Logbook2
Week 3	Logbook2	Logbook2	Logbook2 Physical Mental	Logbook2	Logbook2	Logbook2	Logbook2
Week 4	Logbook2	Logbook2	Logbook2 Physical Mental	Logbook2	Logbook2	Logbook2	Logbook2
Week 5	Logbook2	Logbook2	Logbook2 Physical Mental	Logbook2	Logbook2	Logbook2	Logbook2
Week 6	Logbook2	Logbook2	Logbook2 Physical Mental	Logbook2	Logbook2	Logbook2	Logbook2
Week 7	Logbook2	Logbook2	Logbook2 Physical Mental	Logbook2	Logbook2	Logbook2	Logbook2
Week 8	Logbook2	Logbook2	Logbook2 Physical Mental	Logbook2	Logbook2	Logbook2	Logbook2
Week 9	Logbook2	Logbook2	Logbook2 Physical Mental	Logbook2	Logbook2	Logbook2	Logbook2
Week 10	Logbook2	Logbook2	Logbook2 Physical Mental	Logbook2	Logbook2	Logbook2	Logbook2 Physical Mental SocVal

Figure 2. Participants requirements.

Participants

A convenience sample was used. Participants were required to be involved in a competitive endurance sport and to have taken part in a physical training regime of at least three to four days a week for the two months prior to the research. Athletes with a history of past systematic mental training delivered by a registered sport psychologist were excluded. To assess eligibility, participants were asked to complete a questionnaire regarding the inclusion criteria (see Appendix H). Participants, if selected for the study, were required to sign a consent form (see Appendix I).

According to the literature, between three and five participants are necessary to participate in a multiple baseline single-subject design (Patrick & Hrycaiko, 1998; Thelwell & Greenless, 2001). Local endurance sport clubs were contacted and meetings were arranged with the athletes and coaches. Free mental training and physiological testing was offered to participating athletes. Participants were selected from clubs involved in running, triathlon, mountain biking, cross-country skiing, and road cycling. Seven participants were recruited to take part in the study. All participants have been involved in their respective sports competition for at least five years and they were currently training an average of five days a week. Demographic information is presented in Table 1.

Table 1. *Participant demographics*

	Mean	SD
Age	30 years	13.63
Weight	64.69 Kg	9.35
Height	174 cm	7.3
BMI	22.41	2.35
Vo2max	54.17 ml/kg/min	12.72

Participants included a 2002 female provincial mountain bike champion, a 2002 provincial road cycling champion, a 1988 Canadian road cycling champion, a 2002 provincial cross country sky champion, two club level competitive cyclists and a club level triathlete. At the end of the research process, each participant was provided with a report of his or her physical and mental skills information.

Task

Participants were requested to complete a mental skills questionnaire to evaluate their perceived mental skills in different areas such as imagery ability, mental preparation, self-confidence, anxiety and worry management, concentration ability, relaxation ability, and motivation (see Appendix A). The questionnaire was completed prior to the physical task, during both baseline and post-intervention, for the length of the study. In this manner, the usage of mental skills during baseline and post-intervention was monitored, to evaluate the effect of the psychological skills training program. The mental skills questionnaire used was designed by Bull, Albinson and Shambrook (1996) "to identify strengths and weaknesses and to monitor progress" (p27) of a number of mental skills. The questionnaire clearly differentiates between mental skills and techniques usage, a feature very relevant for this research. Conversely, other questionnaires such as the one used by Patrick and Hrycaiko (1998) and Thelwell and Greenless (2001) inquire about the techniques usage when trying to assess skills. This approach creates an overlap already pinpointed in the mental skills training bibliography; the difference between techniques and skills (Cox, 2002; Vealy, 1988). In this study, mental skills are defined as a self-report measure of the capability of the individual to correctly use the psychological skill training techniques to facilitate performance. Therefore, the participant would only score high if he/she was able to use the implemented techniques to improve his/her imagery ability, mental preparation, self-confidence, relaxation, concentration, motivation and worry management. The appointed mental skills have been conceived as facilitative of the performance (Hardy et al., 1996; Scott et al., 1999)

Participants were also required to complete a non-maximal incremental workload test on a cycle ergometer, while monitoring their gas production and consumption and heart rate, to determine the power output at ventilatory anaerobic threshold. The tests were completed at the participant's convenience, once a week during the 12 weeks (Scott et al., 1999).

At the end of the mental training intervention, the participants were asked to complete an open-ended questionnaire about the acceptability and perceived relevance of the intervention (see Appendix J) (Kazdin, 1978a; Wolf, 1978). Furthermore, participants were invited to provide informal qualitative comments about the study and/or the intervention.

Setting and apparatus

The ventilatory anaerobic threshold (VAT) was determined using the gases exchange method with the VAX 800 Sensormedics Vo_2 metabolic analyser. The power output was measured by a Series 800 Sensormedics cycle ergometer. The incremental workload and pedalling cadence was monitored by the ergometer. Ventilatory anaerobic threshold was calculated using the V-slope equation (Dickstein, Barvik, Aasland, Snappinn, & Karlsson, 1990) between VCO_2 and VO_2 to predict power output (Watts) at ventilatory anaerobic threshold (Beaver, Wasserman, & Whipp, 1986; Caiozzo et al., 1982; Heitkamp, 2001; Magalan & Grant, 1995; Washington, 1999; Wasserman, 1978; Wasserman, Beaver, & Whipp, 1990; Wasserman & Whipp, 1973). The calculation of the VAT following this method is done by drawing two linear regressions with the VCO_2 / VO_2 plots during an increasing workload. The computer calculates two segment model plots for VCO_2 versus VO_2, the point where the two linear regressions seam represents the Ventilatory threshold (Vt). This point represents an incident in the body which is corroborated by a number of physiological changes. When computer calculation was unfeasible, Hopkins and McKenzie's (1994) recommendations for visual determination were followed using two observers. Independent, well instructed observers were used. In case of disagreement between the two observers, the Vt can be denoted as the mean of the individual threshold determinations (see Appendix K) (Bischoff & Duffin,1995). A compound of different criteria was used for the inter-observer Vt determination, using visual inspection of the plots of the following values: Ve / time, Ve /VO_2, Ve/VCO_2, $PETO_2$ / $PETCO_2$, VCO_2/CO_2, RER and RQ (Fawkner, Armstrong, Child, & Welsman, 2002; Posner, Gorman, & Cline,1987). Ventilatory threshold can be discerned visually from any of the proposed graphs. Ottenbacher (1986) suggested that observers can diverge from evaluation criteria, therefore, inter observer agreement needs to be met. Overlapping several criteria for the visual determination of the Vt reduces the inter-observer disagreement (Fawkner, Armstrong, Child, & Welsman, 2002). Exclusively on 15 of 84 occasions, it was necessary to use the agreement between observers to determinate the Vt (see Appendix K). Furthermore, only on three occasions was it necessary to calculate a mean between the two observers disagreement.

Vt assessment is "participant friendly" (Davis, 1985, p. 10) when compared with other methods of anaerobic threshold calculation. Also, the incremental test does not need to be maximal, which makes it even more acceptable by coaches and participants (Mahon & Cheatham, 2002). No warm-up period is conducted; however, participants were encouraged to stretch before the test. The increasing workload was 20 Watts/minute for a maximum time of 10 to 12 minutes, depending on the participant's physical ability (Carta, Aru, Babieri, & Mele, 1991; Sleivert, 2001; Stockhausen, Grathwohl, Burklin, Spranz, & Keul, 1997). The pedalling cadence was kept constant at a pace decided individually by each participant, in most cases around 80 to 90 rpm (Billar, Mille-Hamard, Pettit, & Koralsztein, 1999; Woolford, Withers, Craig, Stanef, & McKenzie, 1999). Cadence must be kept constant because of its effects over hemodynamics and energy cost, particularly VO2 consumption (Belli & Hintzy, 2002; Vercruysenn, Brisswalter, Hausswirth, Bernard, & Vallier, 2002; Zoladz, Duda, & Majerczak 1998). Power output at Vt has been presented as a great index of change in exercise tolerance induced by training, medication, or other intervention (Friel, 1999; Hebestreit, Stachen, & Heberstreit, 2000; Wasserman, Beaver, & Whipp, 1990).

Heart rate during each physical test was monitored every five seconds by a Polar XTRAINER Plus, by Polar Electro Oy. Each test was individually saved into a file and interfaced using a Polar Advantage unit, to the Polar precision performance software, version 2.10.009, by Polar Electro Oy. This software allows the researcher to study and analyse the data recorded during each workout both individually or by visual comparisons between tests.

Pilot Study

A pilot study was conducted to assess the face validity and reliability of the instruments used in the study. The mental skill questionnaire (see Appendix A) was completed by a convenience sample of 10 Kinesiology students. All the participants understood and were clear about the instructions to complete the questionnaire. Face validity was accepted after visual inspection of the data collected and feedback from the participants (Davis & Gass, 1981). As the tool was designed merely to estimate “strength and weakness” on a number of mental skills, no further validity analysis were completed (Bull, Albinson, & Shambrook, 1996)(p27) . The tool attempts a completely descriptive goal, not a predictive one.

Due to the controversies surrounding the research on the Ventilatory threshold in the last decade, a pilot study was necessary to test instrumentation and assure the reliability of the equipment. Several advantages of using this endurance performance test have already been described, but primarily it is a non invasive and participant friendly test. Ten individuals were tested and retested to assess both the reliability and the possible difficulties determining the Vt. Data illustrated that two major factors were causing the measure to vary individual breathing patterns and apparatus noises (Wyatt, 1999). An interobserver assessment criteria sheet was created and tested with the independent observers (see Appendix K). The calibration protocols were completed attentively before each test for both flow and gases, to minimize error in the data collection. The pilot study supported the recent findings in the literature supporting the Vt as a reliable, non-invasive index of aerobic ability (Gaskill, et al. 2001; Mahon & Cheatman, 2002). The major source of variability on the Vt determination was individual breathing patterns.

Data Analysis

Internal validity is concerned with the extent to which treatment is responsible for observed changes. To ensure that the intervention accounted for the observed changes, confounding variables needed to be taken into account. Extraneous variables interfering with the implementation presents a threat to the internal validity. The most important variables affecting the power output at ventilatory threshold are the frequency, intensity, and volume of physical training (Bompa, 1999). Therefore, these were individually monitored during the study.

Two criteria have been used to evaluate the treatment effects in a single-subject design: the experimental criterion and the therapeutic criterion (Kazdin,1978a, 1978b). Experimental criterion involves demonstration that performance on a given phase has changed. Basically, the experimental criterion evaluates if the intervention has had an effect upon the dependent variables (Barlow & Hersen, 1984; Kratochwill & Levin, 1992). The therapeutic criterion attends to other aspects of the effects of the intervention such as the applied or clinical value and significance of the intervention which are sometimes overlooked. Does mental training enhance the participants functioning in everyday training and competitions? In concert with this criterion is social validation (see Appendix J) which refers to the participants perceived relevance of the goals of the treatment, the procedures, and the outcomes (Foster & Mash, 1999; Martin & Hrycaiko, 1983).

Experimental Criterion

Visual analysis has been appointed as the gold standard to assess the effects of the intervention in single-subject design (Siedentop, 1979; Skinner,1966). However, DeProspero and Cohen (1979) discovered that visual analysis can be non-reliable, when comparing visual analysis of independent observers with statistical analysis. Likewise, White (1971) demonstrated that for behaviours without a dramatic change, individuals misinterpreted as “accelerating” decelerating trends and vice versa. Particularly in situations where the variability is high, some simple statistical analyses have proved to be useful providing a “yardstick” for the analysis (DeProspero & Cohen, 1979). The argument regarding the use of statistical analysis on single-subject design studies needs to be based on a true understanding of the design. This design is not based on a “sampling logic”, and there is no attempt to generalize results to a population. The experimental criterion studies changes between the baseline and post-intervention on four major criteria; mean, trend, level, and latency. The mean refers to the average rate of performance (Kazdin, 1978b). Means can be observed visually in Figure 3.

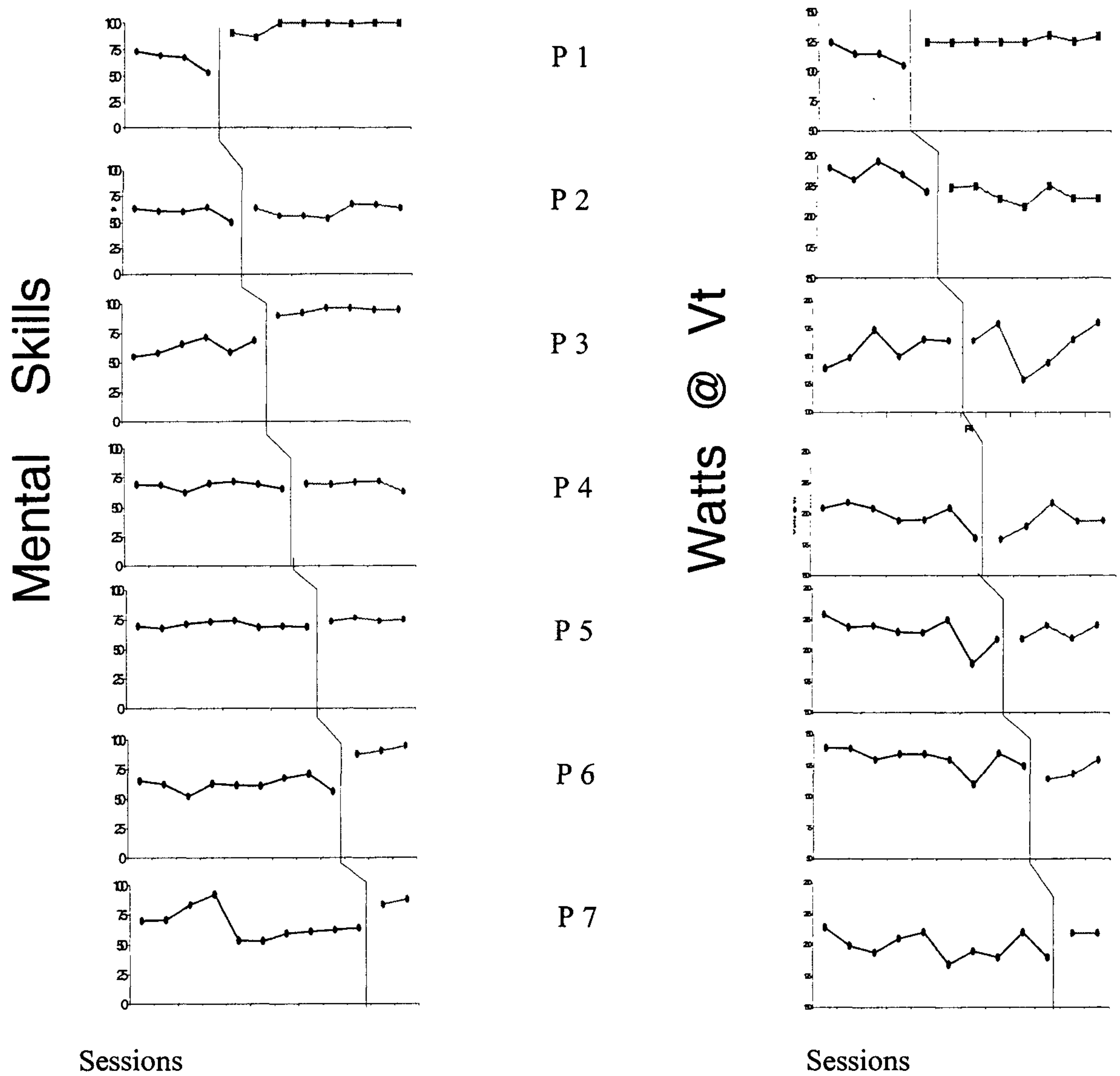

Figure 3. Means for the mental skills scores (left column) and power output at ventilatory threshold (right column) during baseline and intervention for each participant.

Table 2 provides information of the mental skills average scores for each one of the tests completed by each participant during both baseline and post-intervention.

Possible mental skills scores range from 0 to 100. All the participants demonstrated a marked increase, with a mean effect size of 39.53%. Glass Delta score (△) is also provided for each participant. Glass's effect size is calculated by dividing the difference between intervention means by the standard deviation of the baseline (Rosenthal, 1994). Particularly interesting are the increments by participants one, three, and six, indicating an improvement percentage of 50%. Glass's effect size has been selected as an objective statistical mark complementing occasional low reliability between independent observers using visual analysis (DeProspero & Cohen, 1979; White, 1971).

Table 2. *Mental skills baseline, post-intervention and effect size*

	Baseline		Post-Intervention		Effect Size	
	X	SD	X	SD	△	%
P 1	65.47	9.07	97.18	5.18	3.49	50
P 2	59.64	5.65	61.08	5.6	0.25	10.3
P 3	65.32	5.31	94.04	2.55	5.4	50
P 4	68.28	9.87	70.53	0.58	0.71	26.4
P 5	61.9	5.67	90.87	3.58	1.84	46.8
P 6	70.38	2.41	74.85	1.4	5.1	50
P 7	66.6	12.79	85.71	3.365	1.49	43.2
	X= 65.37		X= 82.03			39.53

The lowest improvement recorded was by participant two, with a 10% improvement only. This participant mentioned suffering marital difficulties during the intervention which may have affected his scoring on the mental skills questionnaires.

The reductions in the variability of the mental skills means between the baseline (7.25%) and the post-intervention (3.17%) are extremely meaningful. The intervention, apart from enhancing the overall mental skills scores, reduced at the same time, the variability on the mental skills self-perception. Stability and consistency over time on the mental game, has been mentioned as an important factor in professional sports (Anderson, 2000; Bull, Albinson, & Shambrook, 1996).

Positive changes on the level criteria, which refers to the shift or discontinuity from the end of one phase to the next, was also accomplished as every participant showed an immediate change on the mental skills score after the interventions (see Figure 4).

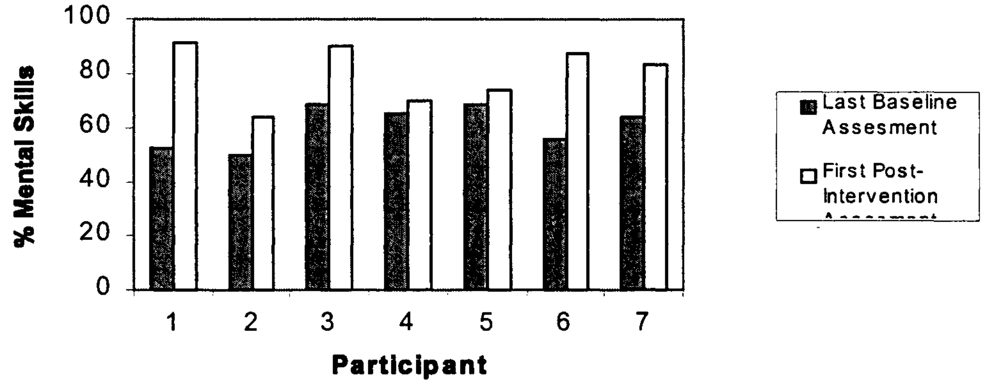

Figure 4. Level analysis for mental skills scores between last baseline and first post-intervention assessments.

Participants four and five showed the least change on the level of response improving between the last assessment on the baseline and the first assessment on the intervention, only 3.69% and 4.50% of improvement on the scores. Participant one and six showed the greatest improvement on the level analysis, 38.69% and 31.55% respectively (see Table 3).

Table 3. *Level analysis by participant*

	P1	P2	P3	P4	P5	P6	P7
Last Baseline	52.38	50	68.45	65.47	68.45	55.95	63.69
First Post-Intv	91.07	63.69	89.88	70.22	73.81	87.5	83.33
Level Change	38.69	3.69	21.43	4.76	5.36	31.55	19.34

Another important criteria is the trend, which refers to the tendency of the data to increase or decrease over the stages. Visual representations of the trends, calculated by the best fit line, can be found in Figure 5. For the mental skills scores only participant four's trend decreased slightly during the post-intervention. Participant five displayed no change in the trend from baseline to post-intervention. All the rest demonstrated a remarkable acceleration.

Participants six and seven showed a considerable change in the directions of the trend lines. Additionally, participants one and three reached the maximal score, thus matching the criteria (see Figure 5). When a participant reaches the maximal score, the trend criteria is satisfied.

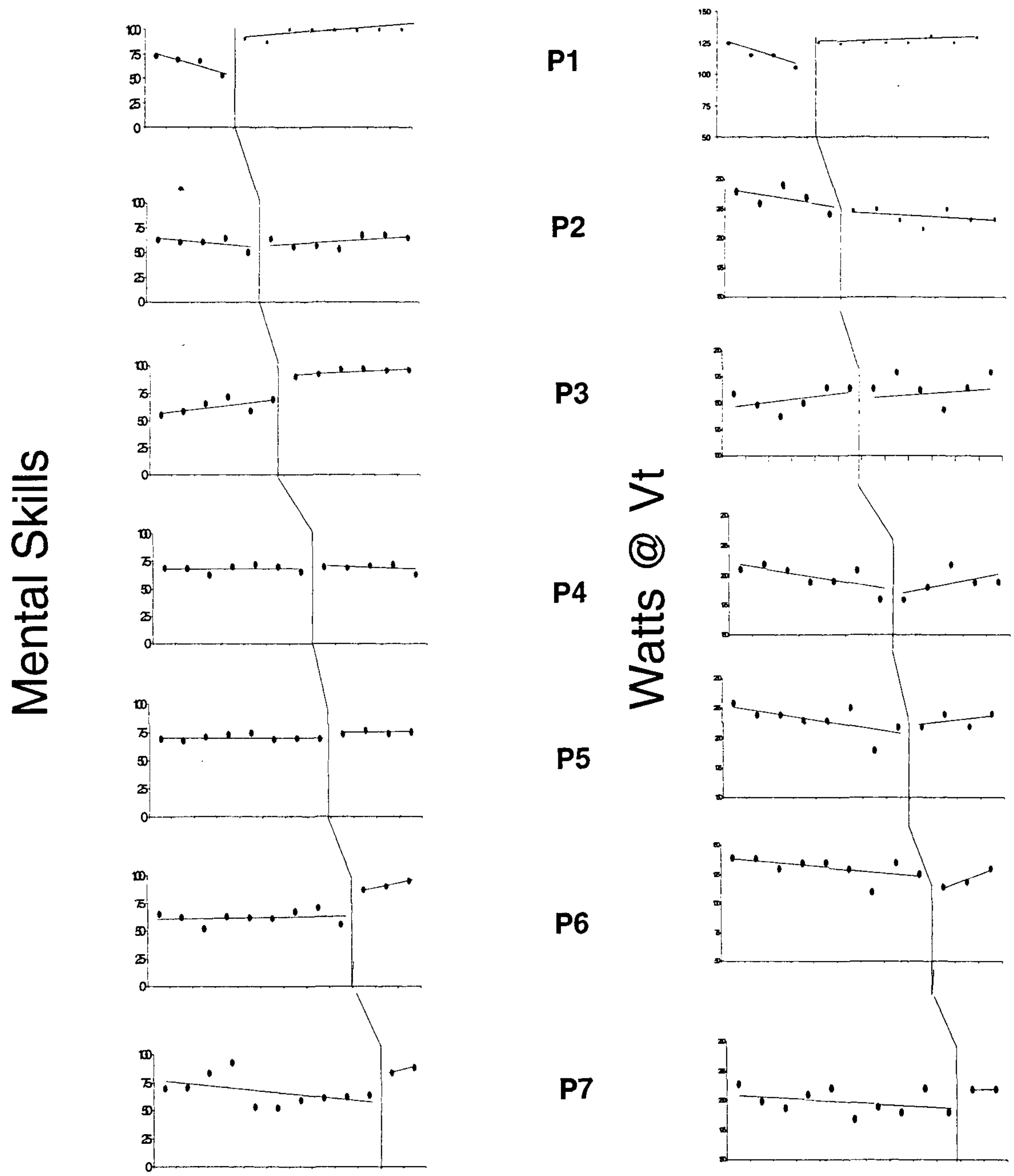

Figure 5. Trends for mental skills and power output at ventilatory threshold trends during baseline and intervention for each participant.

The last experimental criterion is the latency which refers to the abeyance of the changes in the performance between the onset and the end of the post-intervention. This criteria can be visually analysed in Figure 5. Related to the latency period, only participant one displayed some latency on the response after the intervention. It seems that it took two weeks for this participant to reach the highest scores for the mental training. However, this criteria may be understood based on the participant's 38.69% level improvement (see Table 3). Logically, after such a large level improvement, the latency criteria loses relevance.

The experimental criterion for the performance measure, power output at the ventilatory threshold, was analysed based on its four major references; mean, trend, latency, and level. A simple visual analysis of the power output graphs do not reveal as clear improvements as for the mental skills (see Figure 3). An improvement on the power output at ventilatory threshold is illustrated from the means for participants one, three, and seven with increments of 41.10%, 49.50% and 34.10%, respectively (see Table 4).

Table 4. *Means analysis for the recorded power output at ventilatory anaerobic threshold during baseline and post-intervention and individual effects sizes.*

	Baseline		Post-intervention		Effect Size	
	X Watts	SD	X Watts	SD	△	%
P 1	115	8.16	117.5	5	1.34	41.1
P 2	232.8	11.47	218.14	6.59	-1.27	-40
P 3	153.83	10.53	165.75	13.14	1.13	49.5
P 4	199	10.03	193.13	12.22	-0.58	-22.2
P 5	215.25	12.25	214.75	6.06	-0.04	-1.59
P 6	132.33	11.72	120.83	7.76	-0.98	-33.6
P 7	200.92	10.1	209.5	0	1	34.1
	X= 178.44		X= 177.08			

The means analysis of participants two, four, and six, reveal a diminishment on the power output (See Figure 6).

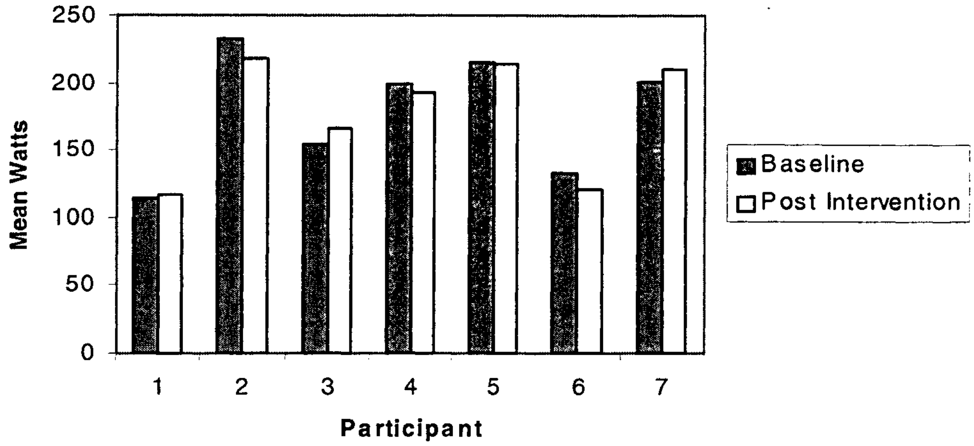

Figure 6. Power output (Watts) during baseline and intervention for each participant.

An analysis of the task efficiency was conducted to analyse the drain or gains in the power output. Gross efficiency, the effectiveness of converting chemical energy into mechanical work (Coast, 1994; Coast, Cox, & Welsh, 1986), was determined as the ratio between the work load and the energy expended (watts/ Vo_2) (Faria, Sjojaard, & BondePetersen, 1982; LaFortune & Cavanagh, 1980). No causal effect appears between the pedalling efficiency and improvements or decrements on the performance. There seems to be no causal relationship (see Figure 7). Participants one and three showed an improvement both in wattage production and gross efficiency from baseline to intervention. The relationship between efficiency and increments or decrements on power output is inconsistent for participants two, six, and seven (see Figure 7).

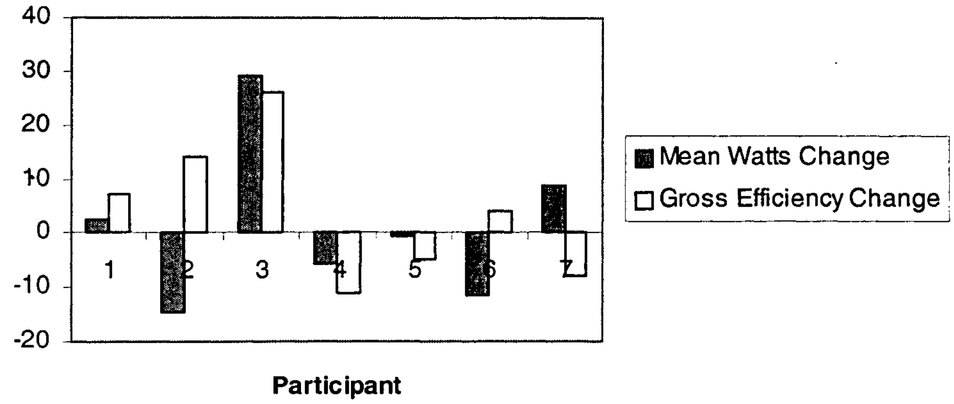

Figure 7. Analysis of change in watts means between baseline and intervention related to gross efficiency change.

Visual analysis of the level criteria is consonant with the means analysis for participant one (see Figure 3). Participant one increased 20 watts from the last baseline assessment to the first intervention. Participant seven paraded exactly the same response increasing the power output by 19.5 watts. The rest of the participants showed no level change on the power output.

To discover if the improvements for participant one and six were due to an improvement in their pedalling efficiency, gross efficiency was derived from the Vo2 consumption readings and 100, 160, and 200 work loads for the two tests under study on the level criteria for each participant. The level criteria studies the last baseline and the first post-intervention test. The results are presented in Figure 8.

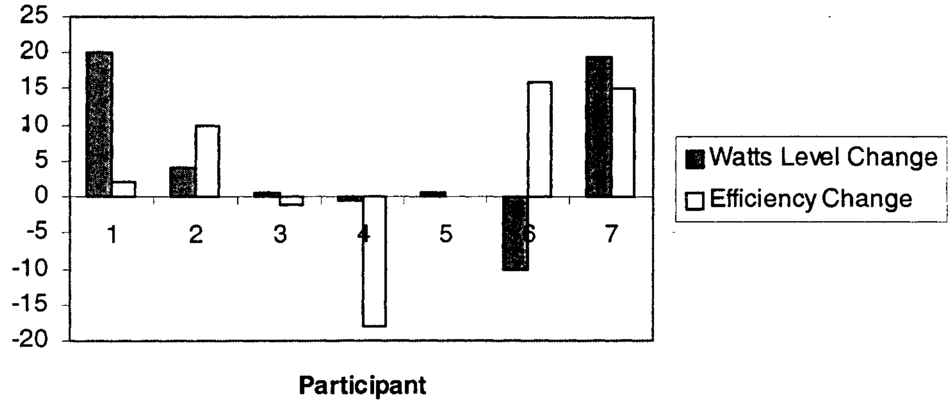

Figure 8. Level changes in power output (watts) and efficiency change.

Three participants showed an enhanced efficiency and an improvement on the power output. However, participant six showed a clear improvement on the level efficiency and a clear reduction on the power output. Again efficiency does not seems to play a role in the power output results.

The visual trend analysis depicts a positive change on the tendency of the data for participants one, four, five, and six. Change in their trends are quite abrupt from the decreasing baseline trend to the increasing post-intervention (see Figure 9).

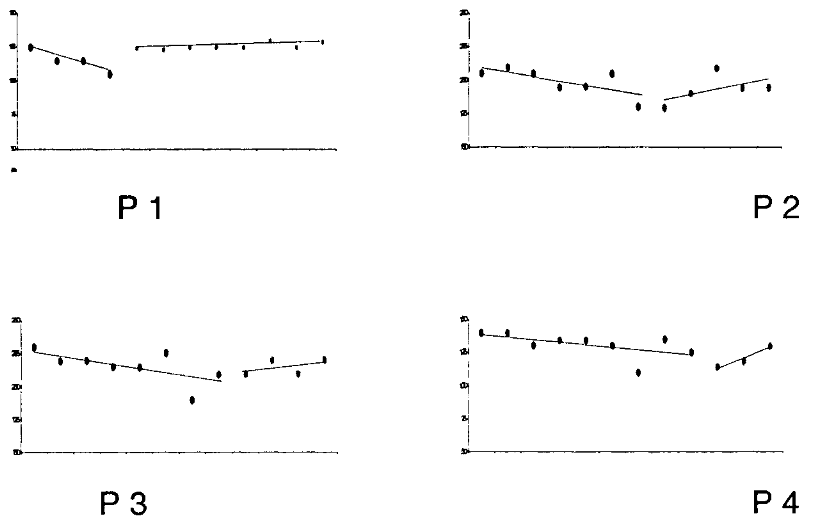

Figure 9. Most significant trend changes on power output between baseline and intervention.

The power output trends visual analysis also indicates that participant three baseline trend was decreasing (see Figure 5). A simple visual analysis of the baseline data points does not reflects an increasing tendency; however, after plotting the trend it is accepted that the intervention should not have been introduced to that participant (Baer, Wolf, & Hersen, 1968). The power output at ventilatory threshold data does not show any latency period.

To assess for other physiological changes, a visual analysis of the average heart rates is presented in Figure 10. No significant reductions in the average heart rates were found, supporting the non existence of physiological adaptations.

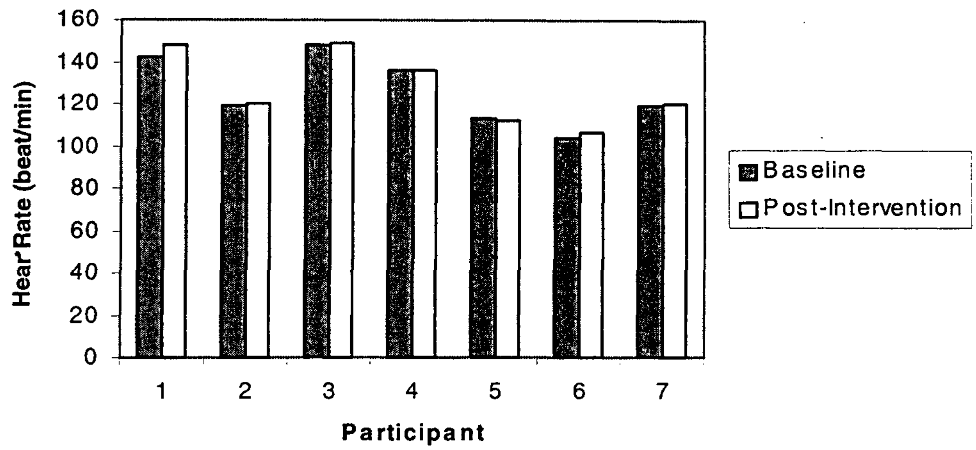

Figure 10. Average hear rate during baseline and post-intervention for each participant.

As an example, Figure 11 plots the entire test heart rate analysis for the first two tests of the baseline and for the last three tests of the post-intervention, showing virtually no differences.

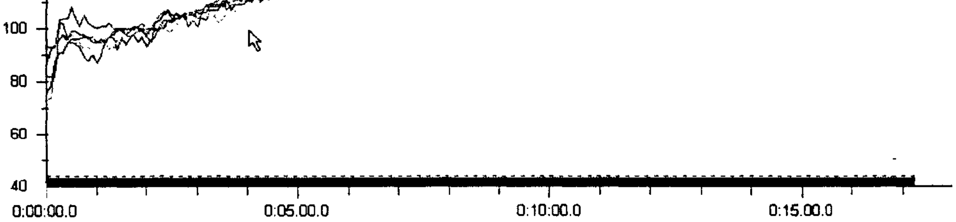

Figure 11 . Heart rate visual analysis for participant four during two baseline and three post-intervention assessments

Therapeutic Criterion

The therapeutic criterion analysis involves the applied part of clinical significance (Barlow & Hersen, 1984). A solid experimental effect does not assure applied significance or real change to the participant functioning. Clinical significance is sometimes more difficult to achieve than experimental or statistical significance. However, in some cases, when the aim is the extinction of the behavior, both statistical and clinical go together. Social validation is an important part of the therapeutic criterion and refers mainly to three different elements of the intervention; the goals of the treatment, the treatment procedures, and the outcomes of the treatment procedures (Foster & Mash, 1999; Kazdin, 1982; Kendal, Hrycaiko, Martin, & Kendall, 1990; Scott et al.,1999). Social validation can be understood as changes in the dependent variable that are recognizable to significant others such as coaches and peers. Nevertheless, in this case, social validation involves only the participants' perceptions (Kazdin, 1977). To assess social validation, participants were asked to complete a number of questions using Likert scales.

Participants were asked how important an improvement in performance was to them. Six of seven participants rated the importance of the intervention goal as extremely important and one participant rated it as fairly important. This assures the social relevance of the intervention goal, performance enhancement (see Figure 12).

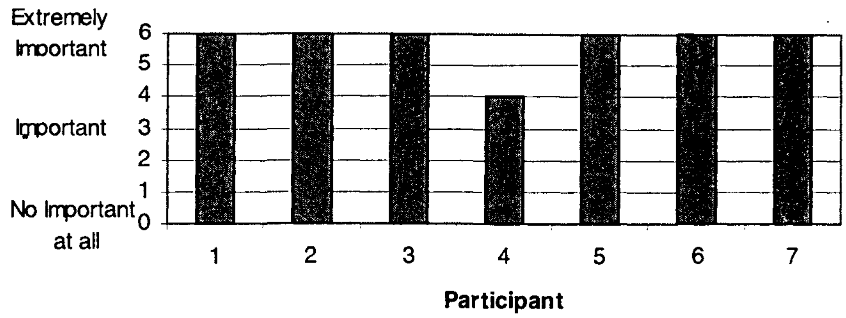

Figure 12. Importance of the intervention goal

When asked about the significance of the changes in their performance, as shown in Figure 13, participants three and four rated the changes in performance as extremely significant, participants two and seven considered them not very significant and participants one, five, and six considered the changes significant.

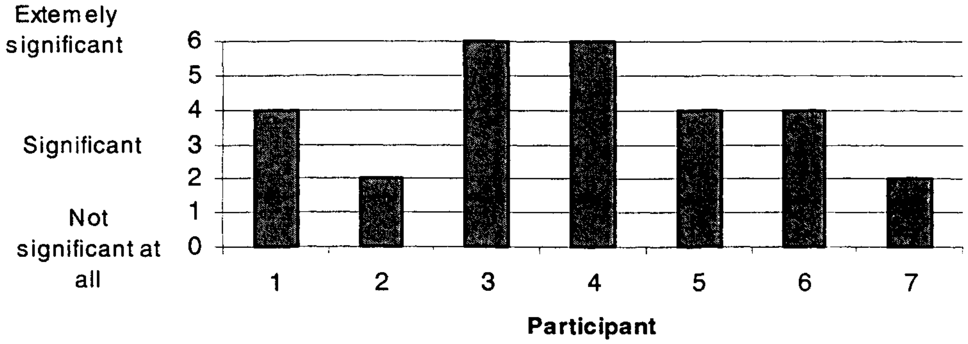

Figure 13. Significance of the changes in performance

Five of the seven participants were extremely satisfied with the mental skills training program: participant two was satisfied and participant four was very satisfied (see Figure 14).

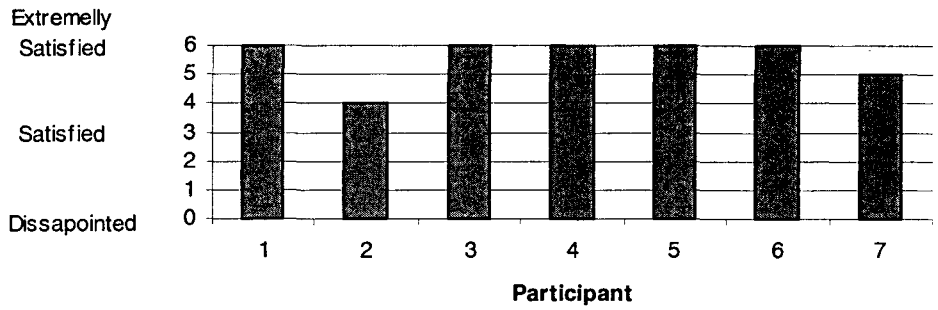

Figure 14. Satisfaction with the Mental skills training program

When asked about the usefulness of the intervention three out of seven rated as extremely useful, two participants as very useful and two more as useful (see Figure15).

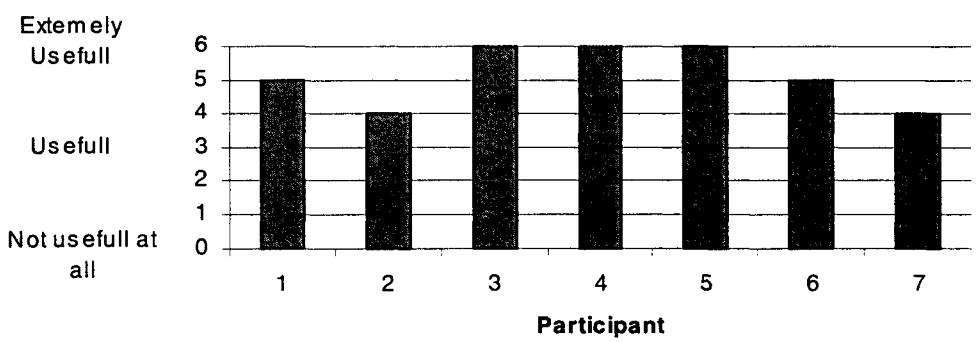

Figure 15. Usefulness of Mental skills training program

To maximize the therapeutic criteria and the clinical relevance, the participants were asked to write any comments and opinions about the intervention and/or the study (see Table 5).

Table 5. *Qualitative comments about the intervention*

P1- "I specially liked the mental training part" " I learned lots about how to keep myself calm and positive before a race and during training as well as during my everyday life" "I am generally more relaxed, open minded, and aware of stimuli that I am unable to control"

P2- aware of "staff that I never paid attention before" "kept me motivated" even during the fall season.

P4- "Study was somewhat lengthy" "It may take months or years to see a huge improvement in performance from mental training" "good learning experience"

P5- "Good review of and idea that I have been slowly forgetting"

P6- "I scheduled the interventions on successive days. If I were to do this again I would space the intervention sessions out so that I had a longer period between each session to review, practice and master it before moving on to the next"

P7- " I think there was improvements on the season performance" I discovered... "subjects that I had not thought about. Ei. Self-talk." this was very useful to me in the future for sports and career"

The qualitative data collected at the end of the study from each participant helped identifying any possible variable interfering or confounding the questionnaire scores, increasing the internal validity (Bisesi & Raphael,1995)

Daily logbooks monitored the frequency, duration, and intensity of the physical training during the baseline. After the intervention, the physical training was prescribed individually to each participant keeping it similar to the baseline period. Table 6 presents the frequency, duration, and intensity of the training during baseline and post-intervention.

Table 6. *Physical training during Baseline and Post-Intervention.*

	Baseline			**Post-Intervention**		
	Frequency Days	Duration Minutes	Intensity Borg Scale (1- 7)	Frequency Days	Duration Minutes	Intensity Borg Scale (1- 7)
P1	4	120	5	2	90	4
P2	6	90	5	4	45	5
P3	5	90	5	7	90	6
P4	4	90	6	3	60	5
P5	5	120	3	3	90	4
P6	3	90	5	3	60	5
P7	5	180	5	4	90	5

Several factors, primarily the weather conditions, contributed to a reduction on the volume of physical training during the post-intervention. During the length of the study, the temperature dropped dramatically, falling to temperatures below 0 Degress Celsius. Temperature is a important factor when taking part in endurance activities outdoors. Also, the reduction on the number of competitions and personal factors made some of the participants to decrease their amount of training.

Discussion

The results present clearly that a short term cognitive behavioral intervention can enhance the self assesment on a number of mental skills such as imagery ability, mental preparation, self-confidence, anxiety and worry management, concentration ability, relaxation ability and motivation, on a group of club level endurance athletes. This outcome is in agreement with Patrick and Hrycaiko (1998) and Thelwell and Greenless (2001), the two previous major papers investigating psychological skill training and endurance performance.

On the other hand, maintaining similar training patterns, the power output at the ventilatory threshold did not illustrate a clear improvement after the intervention. Therefore, it can be argued that the improvements in the endurance performance presented in Patrick and Hrycaiko's (1998) and Thelwell and Greenless (2001) studies are not due to changes in the physiological mechanisms under study.

Finally, the social validation scales and the participants' qualitative comments have revealed the relevance and validity of the goals of the treatment, the treatment procedures, and the outcomes of the treatment for the participants .

The improvement on the self-assessment of the selected mental skills facilitative of the performance unambiguously matches both the experimental and therapeutical criteria. Another critical finding is the large reduction on the day to day variability on the mental skills scores after the intervention. The average standard deviation during the baseline was 7.25%, and during the post-intervention, it was reduced to 3.17%. Consistency, along time on the self-perception and self-concept, has been identified as a crucial factor, particularly in professional sports because of the length and intensity of the seasons. Therefore, apart from an improvement in the skills, the intervention appears to have equipped the participants with stability regarding their perceived abilities.

It can be noted that the improvement in the mental skills after the intervention was not as considerable as the ones reported in the Patrick and Hrycaiko (1998) and Thelwell and Greenless (2001) studies. However, this is due to the differences on the assessment and understanding of the mental skills. Patrick and Hrycaiko (1998) and Thelwell and Greenless (2001) studies appreciated usage of the technique as an indicator of mastering the skill. In this study, a differentiation between technique usage and the perceived mental skills was established. Skills usage was assessed by manipulation checks, and mental skills was assessed by self-assessment questionnaires. The manipulation checks assessed merely the usage of the technique by the participant, in order to ensure that the independent variable was in effect. Apart from the technique usage, a number of mental skills such as self-perception of mental skills as self-confidence, concentration ability, relaxation ability, imagery ability, mental preparation, motivation, anxiety and worry management were assessed using a questionnaire. Patrick and Hrycaiko's (1998) and Thelwell and Greenless's (2001) studies used questions such as - Did you perform a relaxation technique before your ran?,Did you mentally rehearse before you went for your ran?, Did you use imagery in any way during your run?. These questions are clearly assessing the use of the technique and not the perceived ability with the skills. This promotes an overlapping between the study internal validity, the use of the techniques and the assessment of the dependent variable. As an example, manipulation checks of participant two show

how the technique was thoroughly practised; however, the scores for relaxation ability were still low. Therefore, the selected questionnaire assesses if the participant has mastered the usage of the technique with the desired outcome, in this particular case, his relaxation ability.

The educational approach of the intervention collides with the rapid of the intervention. The constrains of the design and the unfeasibility to maintain athletes on the same training schedule for a lengthy period of time obligated the researcher to implement the intervention in a maximum of seven days, perhaps not allowing the participants time enough absorb in all the materials. Particularly relevant are comments from participant six regarding the time between sessions to practise and master the technique, to become comfortable on the specified facilitative mental skills. This educational notion is prominent in the cognitive behavioral approach, presenting the participant as active, autonomous, and self-reliant. However, even accepting the necessity of time to absorb the materials, it is difficult to monitor and prescribe training for such a long period of time. At the same time, in single-subject designs, the interventions must be short to match the level criteria, showing a fast change on the behavior or score from the last baseline to the first intervention assessment.

Individual factors affecting the mental skills scores reinforce the election of single-subject design. In this type of design, attention can be focus on the individual. As an example, participant two was involved in marital difficulties while the intervention was being held. This situation was a threat to his mental skills response, lowering the participant learning and improvement. The design allows an understanding of this situation.

It can be also mentioned the possible effects of the repetitive use of the mental skills questionnaire. The retest artifact can call into question the validity of change (Ormel, Koeter & Van den Brink, 1989). Equally, the Hawthorne effect, a distortion of research results caused by the response of participants to the special attention they receive from the researcher, may have influenced the results.

Contrary to the results in the mental skills area, the power output data does not show an overall positive effect after the intervention. The rationale behind including a performance dependent variable with a physiological base was to determine if the rapid in-field performance improvements shown by these types of interventions (Patrick & Hrycaiko,1998; Thelwell & Greenless, 2001) are based on major physiological adaptations. The answer, as predicted by general physiology knowledge, appears to be negative. The results support the physiology knowledge, indicating the necessity of large periods of time, at least several months to attain changes on these intricate physiological systems. At this point, several hypotheses can be made to try and discover what the action mechanisms are for performance enhancement if the improvement is not derived from major physiological adaptations as presumed. One of them is related to pain tolerance and pain management. It can be hypothesized that athletes after being involved in a mental training program develop general mental awareness, which allows them to cope and understand better the functioning, effects, and mechanism of pain. This general understanding and control provides the athlete an ability to train and perform harder. The increment of the pain tolerance would not be reflected on the power output at ventilatory threshold measure because the physiological base does not change. The change is based on the cognitive evaluation and attitude of the participant over each particular situation.

Power output at ventilatory anaerobic threshold was found to be a reliable measure of endurance performance. Its reliability can be occasionally threatened by individuals' irregular breathing patterns; for example, participant three. The non-invasive and sub-maximal nature of the testing protocol makes it very appropriate, particularly in a study with such a high number of assessments.

Heart rate was also used as a side dependent variable, with the aim of finding cardiovascular adaptations. Its accuracy and simplicity makes heart rate an effective index. The results from the heart rate data analysis show no significant changes from the baseline to the post-intervention stage. The heart rate results also support that there were no physiological adaptations due to the intervention. Even accepting the non-existence of a consistent or significant change on the power output at the ventilatory threshold, there are few particulars that must be reviewed. Foremost, participant one, without an increment in the amount of physical training or matching all the experimental criteria, shows some relevant aspects. There is an important level change and a clear change on the trend of the performance (see Figure 5). Participant one data is particularly interesting because of the resemblance between the mental skills and the power output graphs. In addition, this participant showed the largest change on the mental skills. Carefully analysing the participant's logbooks, one can observe that physical training was slightly reduced, which is also reassured by the increment on his/her average hear rate (see Figure 10). The level improvement is especially significant for this participant. This participant also showed improvements on the efficiency on both mean analysis and level change. This fact may explain, at least in part, the improvement.

Nevertheless, when evaluating both the means and the levels analysis and efficiency, the results are contradictory. Most increments on efficiency did not relate to power output increments and vice-versa. Because of the inconsistency of the efficiency analysis, more research is needed in the area of psychological skills training and task efficiency. Task efficiency research is particularly recommended for evaluating visualization effects especially because the known relation between imagery and neural control. According to the study results, it can be hypothesized that the performance enhancement effect of this type of intervention is not due to the imagery suggested neural effects. Neural and motor control adaptations have been named as the most likely action mechanism for the performance enhancement effects of imagery. Therefore, more research is needed on the relationship between imagery use and task efficiency.

The other point that requires attention on the power output data analysis, is the significant changes on the trends for four of the participants. Even without matching other criteria for experimental change, participant one, two, five, and six showed a clear positive change in the directions of the trends (see Figure 7). Again, this situation has particular relevance due to the minimal training load reductions after the interventions indicated by the participants. However, it must be mentioned that the general analysis did not shown an improvement and that trend analysis is just one of the criteria. The trends analysis findings are difficult to interpret from the overall view of the results. However, it does make sense from the cognitive-behavioral aspect of the intervention.

The intervention presents the techniques, and its use with the passing of time, keeps improving the skills, which affect the performance. However, this assumption is uncertain mainly because the relatively short of the post-interventions.

The dâta from the social validation questionnaires and the qualitative data, shows how the intervention was rated by the participants as "extremely satisfactory" or "very satisfactory". Accordingly, it was rated as "useful" or "extremely useful" by all participants. These results have a particular interest reinforcing the professional consultancy in sport psychology. The experimental criteria has a large value from an accountability point of view, but the satisfaction, usefulness, and significance of the interventions also have a major impact on the credibility and acceptability of the sport psychology profession. The significance of the changes in performance, was likewise positively rated by the participants. In general, the social validity results are totally in concordance with Patrick and Hrycaiko (1998) and Thelwell and Greenless (2001) findings. This unanimity reinforces the idea, that having found no significant changes on the power output at ventilatory threshold, does not assure no improvement on the final applied performance.

In this kind of research, social validation data has a particular importance because showing a reliable treatment effect through visual inspection or statistical analysis, has no imperative bearing on the significance of the change for individuals.

A major criticism of the single-subject design is its lack of external validity, which refers to the ability to apply results of a study to other settings, participants, and times (McReynolds & Kearns, 1983). The base for external validity and generalization on a single-subject design comes from direct and systematic replication (Thomas, 1984).

Probability statistics are not used to generalized results; instead replication is the key for generalization (Bisesi & Raphael, 1995).

With the goal of increasing the internal validity, the physical training during the study was mônitored during the baseline (see Appendix F) and prescribed (see Appendix B), keeping it stable, during the post-intervention. This lack of control detected in previous research was a threat to the internal validity; whereas, changes in the dependent variable, physical performance, can be attributed to other extraneous variables (Patrick & Hrycaiko, 1998; Thelwell & Greenless, 2001). After reviewing the post-intervention diaries (See Appendix B), even having prescribed the training load, a light reduction on the volume of the physical training occurred. Nevertheless, homogeneity of physical training during the baseline and intervention was established. Several factors influenced this diminutive reduction. First, the weather conditions in the northern latitude affected the hours of training of the participants. Four of the participants were cyclists and this activity involves long training hours that cannot be completed below zero degrees Celsius. Another factor was the competition load. There are few competitions at this particular time of the year. Finally, other commitments of the participants reduced the volume of training in particular weeks during the post-intervention.

Recommendations for General Practice

The cognitive-behavioral model has offered a reference point to assist in understanding every aspect of the intervention and analysis. Sport psychology as an applied science has been using several models. However, the cognitive-behavioral model includes the psychological skill training paradigm frequently used by practitioners without a clear theoretical background. Also the presentation of a unifying and research based model to the athlete helped resolve doubts and concerns about the intervention and allowed a clear rationale for the use of each of the techniques. The scientific approach of the model makes it befitting for daily practice.

Because of the design restrictions, the length of the intervention had to be reduced to one week. Nevertheless, due to the educational approach to the intervention, a period of at least three months is optimal in maximizing the positive effects. Preferably, the intervention should be started in the pre season. In this manner, the athlete through repetitive use of the techniques, would be able to master the desired mental skills facilitative for the performance.

Previous research shows how imagery ability, mental preparation, self-confidence, anxiety and worry management, concentration ability, relaxation ability and motivation are facilitative of the performance, across sports and levels of the practitioners; therefore, developing these mental skills could be a goal itself.

Participant five's comments suggest a new area of development for this type of intervention. The participant claimed that the intervention was really helpful, not just for performance enhancement purposes but also for exercise adherence. This introduces the idea of the use of this kind of program for exercise prescription and adherence.

This suggestion relates to the new tendencies in the area of physical fitness and wellness, where the psychological and spiritual aspects of wellness are an important factor, sometimes underestimated.

Although the cognitive-behavioral model has been validated through different cultures and educational levels, research in performance enhancement for endurance athletes, has been done with well-educated western society participants, which could lead to erroneous generalizations.

References

Anderson, M. B. (2000). *Doing sport psychology.* Champaign, Human Kinetics.

Baer, D. M., Wolf, M. M., & Risley, T. R . (1968). Some current dimensions of applied behavior analysis. *Journal of Applied Behavior Analysis, 1*, 91-97.

Barlow, D. H., & Hersen, M. (1984). *Single case experimental designs: Strategies for studying behavior change* (2nd ed.). NY: Pergamon.

Beaver, W. L., Wasserman, K., & Whipp, B. J. (1986). A new method for detecting anaerobic threshold by gas exchange. *Journal of Applied Physiology, 60*(6), 2020-2027.

Beck, A. T., & Emery, G. (1985). *Anxiety and phobias: A cognitive perspective.* New York: Basic Books.

Beck, J. S. (1995). *Cognitive theory: Basics and beyond.* New York: The Guildford Press.

Belli, A., & Hintzy, F. (2002). Influence of pedalling rate on the energy cost of cycling in humans. *European Journal of Physiology, 88*, 158-162.

Billar, V. L., Mille-Hamard, L., Pettit, B., & Koralsztein, J. O. (1999). The role of cadence on the VO2 slow component in cycling and running in triathletes. *International Journal of Sports Medicine, 2*(7), 429-437.

Bischoff, M. M., & Duffin, J. (1995). An aid to the determination of the Vt. *European Journal of Applied Physiology, 71*, 65-70.

Bisesi, T. L., & Raphael, T. E. (1995). Combining single-subject experimental designs with qualitative research. I. Newman, & J. McCormick (Eds.), *In Single-Subject experimental research: applications for literacy.* Delaware, USA: International Reading association.

Bryan, A. (1987). Single-subject designs for evaluation of sport psychology interventions. *The Sport Psychologist, 1,* 283-292.

Bompa, T. (1999). Periodization, theory and methodology of training. New York: Kendall/Hunt Publishing.

Borg, G. (1982). Psychological bases of perceived exertion. *Medicine and Science in Sports and Exercise, 14,* 377-381.

Bull, S. J., Albinson, J. G., & Shambrook, C. J. (1996). *The mental game plan: Getting psyched for sport.* Brighton, UK: Sports Dynamics.

Burton, D. (1990). Multimodal stress management in sport: Current status and future directions. In J. Graham., L, Hardy (Eds.), Stress and performance in sport, (135-171). Chichester: John Wiley & Sons.

Carta, P., Aru, G., Babieri, M. T., & Mele, M. (1991). Bicycle ergometry exercise tests: A comparison between three protocols with an increasing load. *Medicine Law, 82,* 56-64.

Caiozzo, V. J., Davis, J. A., Elli, J. F., Azus, J. L., Vandagriff, R., & Prieto, C. A. (1982). A comparison of gas exchange indices used to detect the anaerobic threshold. *Journal of Applied Physiology, 53,* 1184-1189.

Coaching Association Canada (1987). *Visualization: What you see is what you get.* Ontario, Canada: Coaching Association Canada.

Coast, J. R. (1994). Re-examining optimal cycling cadence. *Cycling Science, 6*(1), 1-18.

Coast, J. R., Cox, R. H., & Welch, H. G. (1986). Optimal pedalling rate in prolonged bouts of cycle ergometry. *Medicine & Science Sports Exercise, 18,* 225-230.

Cox, R. H. (2002).*Sport psychology: Concepts and applications* (5th ed.). McGraw-Hill.

Daniels, J .T., Yarbourgh, R. A., & Foster, C. (1978). Changes in Vo2max and running performance with training. *European Journal of Applied Physiology, 39,* 249-254.

Davis, J. A., & Gass, G. C. (1981). Anaerobic threshold as determined before and during lactic acidosis. *European Journal of Applied Physiology 47*(2), 141-149.

Davis, J. A. (1985). Anaerobic threshold: Review of the concept and directions for future research. *Medicine and Science in Sports and Exercise, 17*(1), 6-18.

De Francesco, C., & Burke, K. L. (1997). Performance enhancement strategies used in a professional tennis tournament. *International Journal of Sport Psychology, 28,* 185-195.

De Francesco, C., & Cronin, J. (1988). Marketing the sport psychologist. *The Sport Psychologist, 2,* 28-38.

De Prospero, A., & Cohen, S. (1979). Inconsistent visual analyses of intra subject data. *Journal of Applied Behavior Analysis,12,* 573-579.

Desiderato, O., & Miller, I. B. (1979). Improving tennis performance by cognitive behaviour modification techniques. *Behaviour Therapist, 2,* 19.

Dickstein, K., Barvik, S., Aasland, R. N, Snappinn, S., & Karlsson, J. (1990). A comparison of methodologies in detection of the anaerobic threshold. *Circulation, 81*(2) 38-46.

Diekhoff, G. (1992). *Statistics for the behavioural sciences: Univariate, bivariate, & multivariate.* Dubuque: Wm. C. Brown.

Dobson, K. S., & Khatri, N. (2000). Cognitive therapy: Looking backward, looking forward. *Journal of Clinical Psychology, 56*(7) 907-923.

Eynsenck, H. J. (1952). The effects of psychotherapy: An evaluation. *Journal of Consulting Psychology, 16,* 319-324.

Faria, I., Sjojaard, G., & BondePetersen, F. (1982). Oxygen cost during different pedalling speeds for constant power output. *Journal of Sports Medicine, 22*, 295-299.

Farrel, P. E., Wilmore, J. H., & Coyle, E. F. (1979). Plasma lactate accumulation and distance running performance. *Medicine and Science in Sports and Exercise, 11,* 338-344.

Fawkner, S. G., Armstrong, N., Child, D. J., & Welsman, J. R. (2002). Reliability of the visually identified ventilatory thresholds and v-slope in children. *Pediatric Exercise Science, 14*(20), 181-192.

Foster, S. L., & Mash, E. J. (1999). Assessing social validity in clinical treatment research issues and procedures. *Journal of Consulting and Clinical Psychology, 67*(3), 308-319.

Foster, C., Pollock, M. L., Farrell, P. A., Maksud, M. G., Anholm, J. D., & Hare, J. (1982). Training responses of speed skaters during a competitive season. *Research Quarterly for Exercise and Sport, 53,* 243-246.

Franklin, R. D., Allison, D. B., & Gorman, B. S. (1993). *Design and analysis of single-case design.* New Jersey: Lawrence Erlbaum Associates.

Friel, J. (1999). *The cyclist training bible. A complete training guide for the competitive road cyclist.* London: A&C Black.

Gaskill, S. E., Ruby, B. C., Walker, A. J., Sanchez, O. A., Serfass, R. C., & Leaon, A. S. (2001). Validity and reliability of combining three methods to determine ventilatory threshold. *Medicine and Science in Sports and Exercise, 33*(11), 1841-1848.

Golfried, M. A. (1979). Anxiety reduction through cognitive-behavioural intervention. In P. Kendall & S. Hollon (Eds.), *Cognitive Behavioural Interventions* (pp.117-149) New York: Academic Press.

Gordon, S. (1990). A Mental Skills Training Program for the Western Australian State Cricket Team. *The Sport Psychologist, 4,* 386-399.

Gould, D., & Eklund, R. C. (1991). The application of sport psychology for performance optimizations. *The Journal of Sport Science, 1,* 10-21.

Gould, D., Petlichkoff, P., Hodge, K., & Simons, J. (1990). Evaluating the effectiveness of a psychological skills educational workshop. *The Sport Psychologist, 4,* 249-260.

Gould, D., Weiss, M., & Weinberg, R. (1981). Psychological characteristics of successful and non-successful big ten wrestlers. *Journal of Sport Psychology, 3,* 69-81.

Gravel, R., Lemioux, G., & Ladouceur, R. (1980). Effectiveness of a cognitive behavioural treatment package for cross country ski racers. *Cognitive Therapy and Research, 4*(1), 83-89.

Greenspan, M. J., & Feltz, D. (1989). Psychological interventions with athletes in competitive situations: A review. *The Sport Psychologist, 3,* 219-236.

Grove, R. J., Norton, P. J., Raalte, J. L. V., & Brewer, B. (1999). Stages of change as an outcome measure in the evaluation of mental skills training programs. *The Sport Psychologist, 13,* 107-116.

Hall, H. K., & Erffmeyer, E. (1983). The effect of visuo-motor behavior rehearsal with video tape modelling on free throw accuracy of intercollegiate female basketball players. *Journal of Sport Psychology, 5,* 343-346.

Hamilton, S., & Fremouw, W. (1985). Cognitive-behavioural training for college free-throw performance. *Cognitive Therapy and Research, 9,* 479-483.

Hanson, T., & Newburg, D. (1992). Naturalistic inquiry as a paradigm for doing applied performance enhancement research. *Performance Enhancement, 1*(1), 26-40.

Hardy, J., Gammage, K., & Hall, I. (2001). A descriptive study of athlete self-talk. *The Sport Psychologist, 15,* 306-318.

Hardy, J., & Jones, G. (1994). Current issues and future directions for performance-related research in sport psychology. *Journal of Sport Sciences, 12,* 61-92.

Hardy, L., Jones, G., & Gould, D. (1996). *Understanding psychological preparation for sport: Theory and practice of elite performers.* Chichester: Wiley & Sons.

Hebestreit, H., Stachen, B, & Heberstreit, A. (2000). Ventilatory threshold: A useful method to determine aerobic fitness in children? *Medicine and Science in Sports and Exercise, 32*(1).

Heitkamp, H.C. (2001). *Anaerobic threshold: Methods and reproducibility.* Eberhad-Karls-Universitat Tubingen, Germany: Medizinische Klinik Und Poliklinik.

Hersen, M., & Barlow, D. H. (1976). *Single-case experimental designs: Strategies for studying behaviour change.* New York: Pergamon Press.

Heyman, S. R. (1984). Cognitive Interventions: Theories, applications and cautions. In W. F. Straub & J. M. Williams (Eds.), *Cognitive Sport Psychology.* (pp 289-303). Lansing, NY: Sport Science Associates.

Heyman, S. R. (1987). Research and interventions in sport psychology: Issues encountered in working with an amateur boxer. *The Sport Psychologist, 1,* 208-223.

Hogg, J, M. (2000). *Mental skills for competitive swimmers.* Edmonton: Sport Excel Publishing Inc.

Hollon, S. A., & Kendall, P. C. (1979). Cognitive-Behavioral Interventions: Theory and procedure. In P. C. Kendall & S.D. Hollon (Eds.), *Cognitive Behavioral Interventions* (pp. 445-453). New York: Academic Press

Hollozky, J. O., & Coyle, E. F. (1984). Adaptations of skeletal muscle to endurance exercise and their metabolic consequences. *Journal of Applied Physiology, 56,* 831-838.

Holm, J. E., Beckwith, B. E., Ehde, D. M., & Tinius, T. (1996). Cognitive behavioral Interventions for improving performance in competitive athletes: A controlled treatment outcome study. *International Journal of Sport Psychology, 27,* 463-475.

Hopkins, S. R., & McKenzie, D. C., (1994). The laboratory assessment of endurance performance in cyclists. *Canadian Journal of Applied Physiology, 19*(3), 266-274.

Hrycaiko, D., & Martin, G. L. (1996). Applied research studies with single-subject designs: Why so few? *Journal of Applied Sport Psychology, 8,* 183-199.

Huang, Y. T. (1998). *The effects of aerobic capacity and perceived ability on RPE and affects under the different intensity exercises.* Taiwan: National College of Physical Education and Sport.

Hume, K. M., Martin,G. L., Gonzalez, P., Cracklen, C., & Genthon, S. (1985). A self-monitoring feedback package for improving freestyle figure skating practice. *Journal of International Sport Psychology, 7*(4), 333-345.

Jacobson, E. (1930). *Progressive relaxation.* Chicago: University of Chicago Press.

Jones, R. R. (1978). Invited book review of Single case experimental designs: Strategies for studying behavior change, by Michel Hersen and David H. Barlow. *Journal of Applied Behavior Analysis, 11,* 309-313.

Jones, G. E., & Johnson, H. J., (1980). Heart rate and somatic concomitants of mental imagery. *Psychophysiology, 17,* 339-347.

Kazantzis, N., Deane, F. P., & Ronan, K. P. (2000). Homework assignments in cognitive and behavioral therapy: A meta-analysis. *Clinical Psychology: Science & Practice, 7*(2), 189-202.

Kazdin A. E. (1977). Artifact, bias and complexity of assessment: The ABCs of reliability. *Journal of Applied Behavior Analysis, 10,* 141-150.

Kazdin, A. E. (1978a). Methodological and interpretative problems of single-case experimental designs. *Journal of Consulting and Clinical Psychology, 46*(4), 629-642.

Kazdin, A. E. (1978b). Methodology of applied behavior analysis. IN T. Brigham & A. C. Catania (Eds,), *Handbook of applied behavior research: Social and instructional processes.* New York: Irvington.

Kazdin, A. E. (1982). *Single-case research designs: Methods for clinical and applied settings.* New York: Oxford University Press.

Kazdin, A. E., Hersen, M., & Bellack, A, S. (Eds.) (1983). *The clinical psychology handbook.* New York: Pergamon Press.

Kendall, G., Hrycaiko, D., Martin, G. L., & Kendall, T. (1990). The effects of an imagery rehearsal, relaxation, and self-talk package in basketball game performance. *Journal of Sport and Exercise Psychology, 12*, 157-166.

Kirschenbaum, D. (1985). Proximity and specificity of planning: A position paper. *Cognitive Therapy and Research, 9,* 489-506.

Kirschenbaum, D., & Bale, R. (1979). Cognitive behavioral skills in golf: Brain powers golf. In R. Suinn (Ed.), *Psychology in Sports: Methods and Applications* (pp. 274-287). Minneapolis: Burgess.

Kratochwill, T., & Levin, J. (1992). Single case research design and analysis. London: Lawrence Erlbaum Associates.

Krishef, C. H. (1991). *Fundamental approaches to single-subject design and analysis.* Florida: Krieger.

Kumagai, S., Tanaka, K., Matsura, J., Matsuzaka, K., Hirakoba, H., & Asana, K. (1995). Relationship of the anaerobic threshold with the 5 km, 10 km, and 10 mile races. *European Journal of Applied Physiology, 49,* 13-23.

LaFortune, M. A. & Cavanagh, P. R. (1980). Force effectiveness during cycling. *Medicine & Science in Sports Exercise, 12*, 95-105.

Lamb, K. L., Estons, R. G., & Corns, D. (1999). Reliability or ratings of perceived exertions during progressive treadmill exercise. *British Journal of Sports Medicine, 33*(5), 336-369.

Leahy, R. L., & Holland, S. J. (2001). *Treatment plans and interventions fro depression and anxiety disorders.* NY: The Guilford Press.

Lerner, B. S., Ostrow, A. C., Yura, M. T., & Etzel, E. F. (1996). The effects of goal setting and imagery training programs on free-throw performance of female collegiate basketball players. *The Sport Psychologist, 10,* 382-397.

Magalan, U. J., & Grant, B. J. (1995). Determination of gas exchange threshold by nonparametric regression. *American Journal of Respiratory and Critical Care Medicine, 151*(1), 98-106.

Mahon, A. D., & Cheatham, C. C. (2002). Ventilatory threshold in children: A review. *Pediatric Exercise Science, 14*(1), 16-29.

Mahoney, M., & Avener, M. (1977). Psychology of the elite athlete: An exploratory study. *Cognitive Therapy and Research, 1,* 135-141.

Mahoney, M. J., & Gabriel, T. J. (1987). Psychological Skills and exceptional athletic performance. *The Sport Psychologist, 1,* 181-199.

Martin, G., & Hrycaiko, D. (1983). Effective behavioural coaching: What's all about?. *Journal of Sport Psychology, 5,* 8-20.

McArdle, W.'D., Katch, F. I., & Katch, V. I., (1991). *Exercise physiology. Energy, Nutrition and human performance.* (4th ed.). Baltimore: Williams & Wilkins.

McDougall, M., Scott, D., McFarlane, G, Leblanc, J., & Cormier,T. (2000). Using a single-subject multiple baseline to evaluate the effectiveness of a mental skills package on basketball foul shooting. *Proceedings of the Xth World Sport Psychology Congress, 4,* 105-107.

McReynolds, L.V., & Kearns, K, P.(1983). *Single-Subject Experimental Designs in Communicative Disorders*, University Park Press, Baltimore, MD.

Meichembaum, D. (1977). *Cognitive behaviour modification.* New York: Plenum Press.

Meyers, A. W., Bourgeois, A. E., LeUnes, A., & Murray, N. G. (1998). Mood and psychological skills of elite and sub-elite equestrian athletes. *Journal of Sport Behaviour, 22,* 399-409.

Meyers, A. W., LeUnes, A., & Bourgeois, A. E. (1996). Psychological skills assessments and athletic performance in collegiate rodeo athletes. *Journal of Sport Behavior, 19,* 132-146.

Moyna, N. M., Robertson, R. J., Meckes, C. L., Peoples, J. A., Millich, N. B., & Thompson, P. D. (2001). Intermodal comparison of energy expenditure at exercise intensities corresponding to the perceptual preference range. *Medicine and Science in Sports and Exercise, 33*(8), 1404-1410.

Noel, R. (1980). The effect of visuo-motor behavior rehearsal on tennis performance. *Journal of Sport Psychology, 2*, 221-226.

Orlick, T. (1986). *Psyching for sport: Mental training for athletes.* Campaign, IL: Leisure Press.

Orlick, T., & Partington, J. (1989). *Psyched: Inner views of winning.* Ottawa, Canada, Coaching Association of Canada.

Ormel, J., Koeter, M. W., & Van den Brink, W. (1989). Measuring change with the General Health Questionnaire (GHQ): The problem of retest effects. *Social Psychiatry and Psychiatric Epidemiology, 24*, 227-232

Ottenbacher, K. J. (1986). Reliability and accuracy of visually analyzing graphed data from single-subject designs. *American Journal of Occupational Therapy, 40,* 464-469.

Owen, N., & Lee, C. (1987). Current status of sport psychology. *Australian Psychologist, 22*(1), 62-76.

Patrick, D., & Hrycaiko, D. W. (1998). Effects of a mental training package on an endurance performance. *The Sport Psychologist, 12*, 283-299.

Prapavessis, H., Gordon, S., & Grove, J. R. (1990). Design and implementation of mental skills training programmes: some important considerations. *Sports Coach Camberra, 13*(4), 7-10.

Posner, J. D., Gorman, H. S., & Cline, C. J. (1987). Ventilatory threshold: Measurement and variation with age. *Journal of Applied Physiology, 63*, 1519-1525.

Powers, S. K., Dodd, S., Deadson, R., Byrds, R, & McKnight, T. (1983). Ventilatory threshold, running economy, and distance running performance of trained of trained athletes. *Research Quarterly in Exercise and Sport, 54*, 179-182.

Robertson, R. J., Goss, F. L., & Meltz, K. F. (1998). Perception of physical exertion during dynamic exercise: A tribute to professor Gunnar A V Borg. *Perceptual and Motor Skills, 86*(1) 183-191.

Rosenthal, R. (1994). Parametric measures of effect size. In Cooper, H. & Hedges, L. *The handbook of research synthesis* (pp. 231-244). New York: Russell SAGE.

Rushall, B. S. (1992). *Mental skills training for sports.* Sport Science Associates. California.

Schomer, H. H. (1986). Mental strategies and perceptions of effort of marathon runners. *International Journal of Sport Psychology, 17,* 41-59.

Scott, L. M., Scott, D., Bedic, S. P., & Dowd, J. (1999). The effect of associative and dissociative strategies on rowing ergometer performance. *The Sport Psychologist, 13,* 57-68.

Seabourne, T. G., Weinberg, R. S., & Suinn, R. (1985). Effect of individualized, non-individualized, and package intervention strategies on karate performance. *Journal of Sport Psychology, 7,* 40-50.

Shambrook, C. J., & Bull, S. J. (1996). The use of a single case research design to investigate the efficacy of imagery training. *Journal of Applied Sport Psychology, 8,* 27-43.

Sherman, C. P., & Poczwardowski, A. (2000). Relax!... it ain't easy (or is it?). In M.B. Anderson (Eds.), *Doing sport psychology*, (pp.47-60) Champaign, IL: Human Kinetics.

Siedentop, D. (1979). Research on teaching in physical education. In T. J. Templin & J. L. Olson (Eds.) *Teaching in Physical education.* Champaign, IL: Human Kinetics.

Silva, J. M. (1982). Performance enhancement in competitive sport environments through cognitive intervention. *Behaviour Modification, 6,* 443-463.

Sjodin, B., & Jacobson, I. (1981). Onset of blood lactate accumulation and marathon running performance. *International Journal of Sports Medicine, 2,* 23-26.

Skinner, B. F. (1966) Operant behavior. In W. K. Koing (Eds.). *Operant behavior areas of research and application*, NY: Appleton Century Crofts.

Smith, R. E. (1988). The logic and design of case study research. *The Sport Psychologist, 2,* 1-12.

Sleivert, G.(2001). *Aerobic assessment. Guidelines for athlete assessment in New Zealand sport.* Dunedin, New Zealand.

Stockhausen, W., Grathwohl, D., Burklin, C., Spranz, P., & Keul, J. (1997). Stage duration and increase of work load in incremental testing on a cycle ergometer. *European Journal of Applied Physiology, 76,* 295-301.

Suinn, R. M. (1972). Removing emotional obstacles to learning and performance by visuo-motor behavior rehearsal. *Behavior Therapy, 3,* 308-310.

Suinn, R. M.(1977). Behavioral methods at the Winter Olympic Games. *Behavior Therapy, 8,* 283-284.

Tennenbaum, G. & Bar-Elli, M. (1992). Methodological Issues in sport psychology research. *The Australian Journal of Science and Medicine in Sport, 24*(2), 44-50.

Thelwell, R. C., & Greenless, I. A. (2001). The effects of a mental skills training package on gymnasium triathlon performance. *The Sport Psychologist, 15,* 127-141.

Thomas, E, J. (1984). *Designing interventions for the helping professions.* London. Sage.

Ungerleider, S., Golding, J. M., Porter, K., & Foster, J. (1989). An exploratory examination of cognitive strategies used by masters track and field athletes. *The Sport Psychologist, 3,* 245-253.

Vealy, R. S. (1988). Future directions in the psychological skills training. *The Sport Psychologist, 2,* 318-336.

Vealy, R. S. (1994). Current status and prominent issues in sport psychology interventions. *Medicine and Science in Sport and Exercise, 26,* 495-502.

Vercruysenn, F., Brisswalter, F. F., Hausswirth, C., Bernard, T., & Vallier, J. M. (2002). Influence of cycling cadence on subsequent running performances in triathletes. *Medicine and Science in Sports and Exercise, 34*(3), 530-536.

Wanlin, C. M., Hrycaiko., Martin, G. L., & Mahon, M. (1997). The effects of a goal setting package on the performance of speed skaters. *Journal of Applied Sport Psycholoy, 9*(2), 212-228.

Washington, R. L. (1999). Cardiorespiratory testing: anaerobic threshold/respiratory threshold. *Pediatric Cardiology, 20,* 12-15.

Wasserman, K. (1978). Breathing during exercise. *New England Journal of Medicine, 298,* 780-785.

Wasserman, K., Beaver, W. L., & Whipp, B. J. (1990). Gas exchange theory and the lactic acidosis (anaerobic) threshold. *Circulation, 81, (suppl II)*: 14-30.

Wasserman, K., & Whipp, N. J. (1973). Anaerobic threshold and respiratory gas exchange during exercise. *Journal of Applied Physiology, 35,* 236-246.

Weinberg, R. S., Chan, R., & Jackson, A. (1983). Mental preparation strategies and performance: Is a combination of techniques better than a single technique?. *Journal of Sport Sciences, 1,* 211-216.

Weinberg, R. S., & Gould, D. (1999). *Foundations of sport and exercise psychology.* Champaign, IL: Human Kinetics.

Weinberg, R., Seabourne, T., & Jackson, A.(1981). Effects of visuo-motor behavior rehearsal, relaxation, and imagery on karate performance. *Journal of Sport Psychology, 3*(3), 228-238.

White, O. R. (1971). Pragmatic approaches to progress in the single case. Doctoral dissertation, University of Oregon, University Microfilms, 72-8618, Michigan.

Wilmore, J. H. (1994). *Physiology of sport and exercise.* Champaign, IL: Human Kinetics.

Wollman, N. (1986). Research in imagery and motor performance: Three methodological suggestions. *Journal of Sport Psychology, 8,* 135-138.

Wolf, M. M. (1978). Social validity: The case for subjective measurement or how behavior analysis is finding its heart. *Journal of Applied Behavior Analysis, 11*, 203-214

Woolford, S. M., Withers, R. T., Craig, P. C., Stanef, T., & McKenzie, N. P. (1999). Effect of pedal cadence on the accumulated oxygen deficit, maximal aerobic power and blood lactate transition thresholds of high-performance junior endurance cyclist. *European Journal of Applied Physiology, 80*, 285-291.

Wyatt, F. B. (1999). Comparison of lactate and ventilatory threshold to maximal oxygen consumption: A meta analysis. *Journal of Strength and Conditioning Research,13*(1), 67-71.

Zoladz, J. A., Duda, K., & Majerczak, J. (1998). Vo2/power output relationship and the slow component of oxygen uptake kynetics during cycling at different pedalling rates: Relationship to venous lactate accumulation and blood acid base balance. *Physiological Research, 47*, 427-438.

Zaichowsky, L. D. (1980). Single case experimental designs and sports psychology Reserach. In C.H.Nadeau, W. R. Halliwell, K. M. Newell & G. C. Roberts (Eds.), *Psychology of motor behaviour and sport*- 1979 (pp.171-179) Champaign, Il: Human Kinetics.

Appendices

Appendix A - Mental Skills Questionnaire

MENTAL SKILLS QUESTIONNAIRE

Imagery Ability. During the last [2 days / 7 days]...	Strongly Disagree					Strongly Agree
1- I have rehearsed my sport in my mind.	1	2	3	4	5	6
2- I have rehearsed my skills in my head before I use them.	1	2	3	4	5	6
3- It has been difficult for me to form mental pictures.	1	2	3	4	5	6
4- I have easily been able to imagine how movements feel.	1	2	3	4	5	6
Mental Preparation. During the last [2 days / 7 days] ...						
5- I have always set myself goals in training.	1	2	3	4	5	6
6- I always had very specific goals .	1	2	3	4	5	6
7- I always analysed my performance after I complete a training/competition.	1	2	3	4	5	6
8- I usually set goals that I achieve.	1	2	3	4	5	6
Self-Confidence. During the last [2 days / 7 days] ..						
9- I suffered from lack of confidence about my performance.	1	2	3	4	5	6
10- I approached all trainings/competitions with confident thoughts.	1	2	3	4	5	6
11- My confidence drained away as competitions draw nearer.	1	2	3	4	5	6
12- Throughout training/competitions I kept a positive attitude.	1	2	3	4	5	6
Anxiety and Worry Management. During last [2 days / 7 days]...						
13- I experienced fears about losing.	1	2	3	4	5	6
14- I worried that I will disgrace myself in competitions.	1	2	3	4	5	6
15- I let mistakes worry me when I perform.	1	2	3	4	5	6
16- I worried too much about competing.	1	2	3	4	5	6
Concentration Ability. During the last [2 days 7 days]						
17- My thoughts were often elsewhere during training/competition.	1	2	3	4	5	6
18- My concentration let me down during training/competition.	1	2	3	4	5	6
19- Unexpected noises put me off my performance.	1	2	3	4	5	6
20- Being easily distracted has been a problem for me.	1	2	3	4	5	6

Relaxation Ability. During the last [2 days / 7 days]	Strongly Disagree				Strongly Agree	
21- I have been able to relax myself before a competition.	1	2	3	4	5	6
22- I have become too tense before a competition.	1	2	3	4	5	6
23- Being able to calm myself down has been one of my strong points.	1	2	3	4	5	6
24- I have known how to relax in difficult circumstances	1	2	3	4	5	6
Motivation. During the last [2 days / 7 days]						
25- At training/competitions I have been activated enough to compete well.	1	2	3	4	5	6
26- I really enjoyed a tough training/competition.	1	2	3	4	5	6
27- I have been good at motivating myself.	1	2	3	4	5	6
28- I usually felt that I try my hardest.	1	2	3	4	5	6

Appendix B - Intervention Diary

Intervention Diary

Physical Training: Date: ________________

Duration: ____ hours _____ mins.

Intensity:

Not Intense at all					Extremely Intense	
1	2	3	4	5	6	7

Goals for the day:

1 (Physical)____

2 (Mental)

____

3____

—

Did you use any relaxation technique during the day?

Yes No

Did you use running related imagery during the day?

Yes No

How vivid and controllable was the imagery?

Not at all						Very
1	2	3	4	5	6	7

Did you control and restructure your self-talk during the day?

Yes No

Percentage of total mental skills used:

Appendix C - Self-Awareness Sheet

Self-Talk Awareness Exercise

-When I talk to myself in training or competition, what do I tend to say?

- When I perform well:

-When I perform poorly:

- What do I tend to say when I talk myself out of doing something in training?

-How frequently do I talk to myself in training?

Never						Very often
1	2	3	4	5	6	7

-When I use self-talk do I feel that I am setting myself up for failure or for success? Please comment.

- I know that what I say to myself affects the way I perform because....

Appendix D - Goal Setting Sheet

Goal Setting Personal Sheet

Name: Date:

1- MY MISSION STATEMENT
-
-
-

2- REALISTIC LONG TERM GOAL
-
-
-

3- SHORT TERM AND DAILY GOALS.(to be included in the logbook).
-
-
-

4-PERFORMANCE GOALS
-
-
-

5-SKILLS GOALS
-
-
-

6-MENTAL TRAINING GOALS
-
-
-

7- ATTITUDE GOALS
-
-
-

8- OTHER GOALS
-
-
-

Appendix E- Last Comment

Now that you've completed the mental skills training, you should be a more complete athlete. You now have control over your level of arousal, emotions and mood, thoughts and self-statements, and your overall ability to achieve yours goals. Having completed the training journals and self-assessments, you have a better understanding of how the mental skills work. Keep in mind that mental skills are skills like any others, and you will like have to continue to practice them and develop your ability to use them proficiently. The next step is to formulate a structured plan in order to facilitate proper focus and feelings, both before and during training and competition. Developing pre-competition and competition focus/refocus plans are an ideal way to include mental skills into an integrated preparation strategy. Considering the amount of training involved in attaining your personal goals, don't leave it to chance that you will be focussed and have the appropriate feelings the day of the competition. Mental preparation is the key!

Appendix F - Baseline Diary

Baseline Diary

Date: ________________

Physical training:

Duration: ____ hours _____mins.

Intensity:

Not intense at all					Extremely intense	
1	2	3	4	5	6	7

Comments:

Appendix G - Intervention Protocol

Session # 1	Observer
- Introduction to the implementation (time, length, frequency).	
- Introduction to CBT Model.	
- Techniques presentation, rationale and research evidence.	
- Other athletes' support. Notes from "psych-up"	
- Goal setting information and rationale. Notes.	
-Personal Goals sheet to fill.	
-Daily goals. Diary.	
- Feedback.	
Session # 2	
- Review goal setting process. Goal sheet.	
- Review daily goals.	
- Relaxation: Information and rationale.	
- Relaxation exercise. (Tape).	
- Feedback.	
Session # 3	
- Review goal setting.	
- Review Relaxation.	
- Imagery: Information and rationale. Notes + video.	
-Relaxation and Imagery exercise.	
- Feedback.	
Session # 4	
- Review diary.	
-Review relaxation and imagery.	
- Self-talk information and rationale. Notes.	
- Self-talk awareness. Self-talk record sheet.	
- Thought stopping as a part of self-talk.	

Appendix H - General information

General Information

- Name

- Contact phone number:

- Age:

- Competitive level:

- Which sport do you practice?

- How many times do you usually train a week?

1	2	3	4	5	6	more

- Have you ever had systematic mental training delivered by a registered sport psychologist?

- What is your level of commitment for improving as an athlete?

Not committed at all						Completely committed
1	2	3	4	5	6	7

- How important is performance enhancement in your sport for you?

Not important						Extremely Important
1	2	3	4	5	6	7

Appendix I - Consent Form

Consent Form

My signature on this sheet indicates that I agree to participate in a study by Lakehead University designed by Carlos Ramirez-Garcia and supervised by Joey Farrell, on mental training for endurance performance, and it also indicates that I understand the following:

1. I am a volunteer and can withdraw at any time from the study.
2. There is no risk of physical or psychological harm.
3. The data I provide will be confidential and it will be kept at Lakehead University during 7 years.
4. I will receive a summary of the project, upon request, following the completion of the project.
5. I have passed a complete medical check in the last 6 months.

I have received a thorough explanation about the nature of the study, its purpose, and procedures.

Signature of the Participant ____________ Date ____________

Name (please print) ____________ Telephone number ____________

Appendix J - Social Validation Scale

Social Validation

	Not at all					Very
1-How important is an improvement in performance to you?	1	2	3	4	5	6
2- Do you consider the changes in performance to be significant?	1	2	3	4	5	6
3- How satisfied were you with the mental skills training program?	1	2	3	4	5	6
4- Has the intervention proved useful to you?	1	2	3	4	5	6

Appendix k - Inter-Observer Agreement Chart

	Test	Observer	V-Slope	Criteria	Time	Seconds	% VO2max	Watts
Participant	BL1		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				
1	BL2		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				
	BL3		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				
	BL4		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				
	Int1		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				
	Int2		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				
	Int3		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				
	Int4		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				
	Int5		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				
	Int6		yes ❑ no ❑	1-❑ 2-❑ 3-❑4-❑				