THE EFFECT OF IMAGERY ON THE TRANSFER OF CYCLE ERGOMETER TRAINING TO ON-ICE SKATING SPEED

by

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ABSTRACT

This study investigated the effect of using mental imagery in conjunction with cycle ergometer training on the transfer of this training to on-ice skating speed. Thirty-two male ice hockey players were pre-tested on the 60 ft on-ice skating sprint (60SS), the 120 ft on-ice skating sprint (120SS), and the Wingate 30 s cycle ergometer test. Subjects were assigned to one of three groups: physical training on the cycle ergometer (PT), physical training on the cycle ergometer while engaging in imagery of the on-ice skating sprint (PTMI), and the control (CON). A one-way ANOVA of pre-test scores revealed no significant differences between the groups on the 60SS, 120SS, or on an anaerobic alactic power (AAP) score from the Wingate 30 s cycle ergometer test. Following a six week training period, all subjects were retested. A one-way ANOVA of post-test scores revealed no significant differences between the groups on the 60SS or the 120SS. The PT and PTMI groups scored significantly higher AAP outputs than the CON. These results support the specificity of training hypothesis, but show no support for the use of imagery in conjunction with cycle ergometer training for the enhancement of on-ice skating speed.

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DEDICATION

To my mother for her support
and encouragement.

CHAPTER 1

INTRODUCTION

Sports participants and researchers alike have claimed benefits from the utilization of mental imagery training on sport performance and skill acquisition. For example, 1984 Canadian Olympic diving gold medallist, Sylvie Bernier was one of many athletes who strongly believed in mental imagery. She claimed that until she had imaged her dive effectively she was unable to physically perform the dive (Orlick & Partington, 1986). Hall, Rodgers, and Barr (1990) added that athletes participating in more competitive sport settings use imagery more frequently in practice, competition, and before their events than those athletes involved in less competitive settings. Further, in a recent comprehensive review by Feltz, Landers, and Becker (1988), the authors concluded that learning was facilitated with imagery and suggested that these effects could be replicated and show considerable generality.

Despite these supportive statements, empirical research has provided equivocal results. Several studies have shown that mental imagery makes little contribution to motor skill performance (Eby, 1986; McIntyre, 1987; Mumford & Hall, 1985) while other studies have demonstrated a positive effect (Ryan & Simons, 1982; Weinberg, 1982). Because of the large variability from reported effect sizes in the mental imagery research, investigators have advocated caution in the interpretation of these results. They have pointed to inconsistent imagery content, inappropriate research design, and a disproportionately high percentage of positive studies published in the literature (Greenspan & Feltz, 1989; Howe, 1991; Van Gyn, 1989; Wollman, 1986).

The majority of literature on mental imagery in the sport setting has either focused on the role of imagery in the learning of motor skills (Ryan & Simons, 1981; Wrisberg &

Ragsdale, 1979) or its more short term role in the enhancement of performance (Murphy, Woolfolk, & Budney, 1988; Orlick, 1986; Weinberg, Jackson, & Seabourne, 1985). A recent study by Van Gyn, Wenger, and Gaul (1990) suggested that mental imagery may also serve as a method of enhancing transfer from training to performance. They showed that a group who combined imagery with their physical training on cycle ergometers significantly outperformed other groups in a 40 m sprint on the track. As well, anecdotal evidence from the Canadian Olympic Hockey Team, has suggested that imagery in combination with an off-ice physical training program enhanced on-ice skating acceleration over 60 ft (Wenger, Botterill, & Neary, 1989). These authors suggested that imagery in conjunction with non-specific training may enhance performance more than non-specific training alone. However, Steinbrink-Kelly (1989), working with rowers, was not able to show similar benefits in transfer of training from rowing ergometers to an actual rowing sprint test.

If imagery does enhance the transfer of non-specific physical training to a specific performance, as Van Gyn et al. (1990) have suggested, it could have a critical impact on an athlete's training program and their performance. With the potential benefits from this type of training, and because few studies have been conducted using imagery to enhance transfer, further study of this area was proposed.

One sport that would benefit from such evidence is ice hockey. The sport demands high levels of fitness, but regular play without additional training is unlikely to improve fitness values (Daub et al., 1983). Further, ice time is not usually frequent enough to promote fitness changes, especially when the on-ice time is required for technical and tactical considerations. Therefore, it has often been more convenient to impose physical training loads on hockey players in an off-ice setting. However, the benefits of such non-specific training sessions are a major concern for players who question the relevance of this training at improving their on-ice performance. Indeed, Watson and Sargeant (1986) have demonstrated that power scores on a cycle ergometer do not correlate highly with tests of skating speed. For this reason, the purpose of this study was to determine if engaging in mental imagery of on-ice skating while performing non-specific cycle ergometer training would facilitate the transfer of this training to the specific on-ice skating performance.

Definition of Terms

Mental Imagery - The mental rehearsal of a motor performance in conditions where the auditory, visual or kinesthetic qualities of movement may be experienced (McIntyre, 1987).

Transfer - The gain (or loss) in the capability for responding in one task as a result of practice or experience on some other task (Schmidt, 1988).

CHAPTER 2

REVIEW OF LITERATURE

In this chapter a current review of the imagery literature has been presented under several headings. These included a description of the imagery effect, as well as the theoretical and methodological concerns in the study of imagery. The theoretical concerns reviewed were the lack of a theoretical framework, the content of imagery packages and the locus of the imagery effect, while the methodological concerns included a review of the subject and design characteristics.

IMAGERY EFFECT

As outlined earlier there has been a great deal of support for the use of imagery in sport. Hall et al. (1990) reported that these techniques were frequently used by athletes in conjunction with competition to help maintain focus and self-confidence and to control emotions and arousal. The following studies are among several which attempt to identify the role that imagery plays as an aid to game performance (Murphy et al., 1988; Orlick, 1986; Weinberg et al., 1985). However, the discovery that few athletes use imagery in conjunction with practice (Hall et al., 1990) suggested that it is not being used as a learning aid, despite the commonly held beliefs for its benefits in sport training.

Reviews of the mental imagery literature (Corbin, 1972; Feltz & Landers, 1983; Richardson, 1967) have indicated that these techniques may improve both learning and performance. More recently, in a meta-analytical review of the mental imagery effect size, Feltz et al. (1988) found an ordering of effect sizes which revealed that physical practice alone demonstrated the largest effect size, followed by combined practice (physical practice and mental imagery), mental imagery alone, and no practice conditions. This supported earlier narrative reviews which suggested that mental imagery was more effective than no practice at all but not as effective as physical practice alone (Corbin, 1972; Richardson, 1967; Weinberg, 1982).

Feltz et al. (1988) strongly supported the use of mental imagery to facilitate learning when they identified a mean effect size from their meta-analysis equal to one half of one standard deviation. With this large positive effect size, across studies which were performed on a large number of different tasks, subjects, and research designs, they concluded that the imagery effect was able to be replicated and that it demonstrated considerable generality.

Corbin (1972) and Weinberg (1982) proposed that combined mental and physical practice would be superior to either mental imagery or physical practice alone. No support was found for this position in the meta-analysis by Feltz et al. (1988), although further research was suggested as all but one of the reported studies used a combination of 50% physical practice with 50% mental imagery. In that study, Oxendine (1969) reported that 6:2 and 8:0 ratios between physical practice and mental practice were more effective than either 4:4 or 2:6 ratios in improving a time-on-target score. He noted that the 75% physical practice and 25% mental practice group was slightly more effective than the 100% physical practice group.

Apart from the direct comparison between physical and imagery training effects, many other factors have been examined. These include imagery style, the performer's level of physical skill, the participant's ability to image, the length of imagery practice, and the characteristics of the actual skill to be performed.

Mahoney and Avener (1977) were responsible for categorizing imagery styles as internal or external imagery. Internal imagery is recognized as a dynamic multimodal type of imagery whereby the athlete not only recognizes the visual replication of the action but also experiences a kinesthetic awareness appropriate to the action (Hale, 1982; Mahoney & Avener, 1977). Alternatively, external imagery is associated solely with the visual modality as individuals watch themselves perform from a spectator's perspective. Although some researchers have not shown a relationship between these imaginal styles and performance (Epstein, 1980; Mumford & Hall, 1985), it has generally been accepted that the internal imagery style is more appropriate for sport performance as it more closely resembles the sporting act. In support of this belief, Hale (1982) observed EMG patterns of specific movement responses during internal imagery conditions. However, the area has remained controversial as some researchers have demonstrated that elite performers were more effective and relied on internal imagery more than non-elite performers (Mahoney & Avener, 1977; Rotella, Gansneder, Ojala, & Billing, 1980), while others have not demonstrated any difference between elite and non-elite performers (Hall et al., 1990; Highlen & Bennett, 1979).

It has also been proposed that imagery is more effective for experienced athletes as they have a clearer internal representation of the skill (Denis, 1985; Mumford & Hall, 1985). Indeed, Weinberg (1982) has suggested the need for minimum skill proficiency for imagery to be effective. In contrast, McIntyre (1987) demonstrated a positive mental imagery effect for non-elite basketball players as they increased the consistency of their performance, although this did not negate the possibility that these subjects still needed some prior experience at the skill. Feltz et al. (1988) noted that other investigators have not demonstrated any significant differences between effect sizes for novice or experienced athletes.

The ability with which an individual images has been proposed as a factor in the degree to which mental imagery may be able to enhance motor skills (Housner & Hoffman, 1981;

Ryan & Simons, 1982). Unfortunately, few studies in this area have been reported. Increased performance has been demonstrated for subjects with high imagery ability (Housner & Hoffman, 1981; Ryan & Simons, 1982), while other investigators have failed to show such effects (Eby, 1986; Epstein, 1980; White, Ashston, & Lewis, 1979). Hall, Pongrac and Buckholz (1985) suggested that these research inconsistencies were most likely due to the differences in the degree to which imagery tests accurately measured a movement component. Tests of imagery ability rely on a verbal representation of the image and therefore are likely subject to the usual interpretive problems.

The effect of the number and length of imagery sessions was another factor reviewed for its potential impact on motor skills. Corbin (1972) has suggested that there is an optimal length and number of practice sessions in which imagery is most effective, while Denis (1985) has added that overly extensive mental practice sessions may be detrimental to performance. An early review of the mental imagery research recommended 5 minutes to be the optimal time that concentration could be maintained in mental practice (Twining, 1949). More recently, Shick (1970) advocated 3 minute sessions, and Feltz and Landers (1983) found that sessions under 1 minute in length or between 15 and 25 minutes demonstrated the largest effect. Feltz and Landers (1983) found a curvilinear relationship between the length of practice and the effect size although this was not supported in a more recent review (Feltz et al., 1988).

Task characteristics have been shown to affect the benefits of mental imagery. Tasks which require high cognitive or symbolic components are more effectively enhanced through the application of mental imagery techniques (Feltz & Landers, 1983; Wrisberg & Ragsdale, 1979). The more recent meta-analysis (Feltz et al., 1988) which separated tasks into cognitive, motor, strength, and endurance tasks, found that most of the variation was associated with tasks that were primarily motor in nature.

A second task characteristic which has been reported to impact on the way imagery affects motor skills was the open or closed nature of the skill. A closed skill is performed in an environment where the critical cues for performance of the skill are static (Poulton, 1957) while an open skill is performed in an environment with constantly changing cues (Marteniuk, 1976). It has been speculated that the performance of closed skills may gain more from mental imagery than open skills (Feltz & Landers, 1983), although McFadden (1982) hypothesized that kinesthetic imagery may be most beneficial for closed skills while visual imagery may be most appropriate for open skills.

Although the positive effect of mental imagery is now more widely accepted for enhancing motor task performance (Feltz et al., 1988; Hall et al., 1990), some researchers believe that this empirical evidence should be approached with caution. Greenspan and Feltz (1989) have questioned the validity of the size of the positive mental imagery effects as well as the high percentage of positive studies reported in the literature. They commented that these studies may have misrepresented the field and suggested that journal editors have a tendency to accept studies showing positive effects over those reporting no effects. Further, they acknowledged that researchers may be more inclined to submit studies which demonstrate positive effects only.

THEORETICAL CONCERNS

Lack of a Theoretical Framework

The majority of studies in mental imagery have treated imagery as an all encompassing phenomenon with a single purpose (Howe, 1991). At present, the most accepted framework for the study of imagery was established by Paivio in 1985. He suggested that imagery may play a cognitive or motivational role in affecting behavior at either a general or specific level. In this model, the general motivational level referred to an amount of physiological arousal and the emotion that may accompany it, while the specific level of motivation was concerned with goal-oriented activity. The general cognitive level was associated with behavioral strategies while the specific level was involved with the development of motor skills.

At present, it seems that the majority of athletes use imagery for improving self-confidence, motivation, focus, and the control of emotion and arousal (Hall et al., 1990). Despite this, the majority of research has focused on the cognitive domain and examined whether mental imagery strengthened correct responses or weakened incorrect responses (Feltz & Landers, 1983; Paivio, 1985). Paivio further questioned the lack of experimental research on the motivational aspects of mental imagery and suggested that this may be used to increase overt practice and performance skills.

In an attempt to expand this framework, Van Gyn (1989) has made two major additions to Paivio's model. The first addition centered on isolating the locus of effect with appropriate consideration for the differences between learning and performance, while the second revision focused on an awareness for the content of the image. Several investigators have recommended continued research to help isolate the components of the imagery package responsible for the imagery effect. If this occurred, imagery theory could then be challenged and organized to allow practitioners more confidence in its application and success (Feltz & Landers, 1983; Howe, 1991; Paivio, 1985; Van Gyn, 1989).

Content of Imagery Packages

To determine the effectiveness of a mental imagery program it is necessary to separate the elements of the program (Paivio, 1985). However, problems exist with the variability of training programs in the literature and these make the replication of studies difficult

(Howe, 1991). In noting its importance, Van Gyn (1989) suggested that the specific content of an image would determine the potential benefits from a cognitive or affective domain.

Van Gyn (1989) classified the content of imagery packages in the literature into three main forms: recreative imagery which focuses on the recreation of past performance in one's mind; creative imagery which develops a potential future performance not yet accomplished in a physical sense, and; cue dependent or emotive imagery which attempts to invoke an improved performance with imagery not directly related to the task. Van Gyn (1989) has suggested potential effects for cognition and affect in both learning and performance for each of the three forms of imagery. Although all three forms of mental imagery have been advocated by sport psychologists (Nideffer, 1985; Orlick, 1986) most empirical studies have focused on recreative imagery.

One of the most typical elements of an imagery program is a preliminary relaxation component. Suinn (1972a, 1972b) developed a technique which he termed visuomotor behavior rehearsal (VMBR) that combined visual imagery and relaxation. This technique required an individual to relax physically and then to image the successful execution of sport specific movements. Several other investigators have supported the use of such packages which control arousal during imagery over those strategies using imagery or relaxation alone (Hall & Erffmeyer, 1983; Weinberg, Seabourne, & Jackson, 1981; Wrisberg & Anshel, 1989).

Relaxation has also been used as a form of emotive imagery to enhance dissociation from pain and prepare for fine motor skills. Murphy and Woolfolk (1987) found that relaxation and control groups improved putting performance in golf while a "psych-up arousal" group did not. However, the nature of the task may be critical as a reduction in performance of a muscular strength task was demonstrated with the use of relaxation (Murphy et al., 1988).

The use of emotive imagery to improve motor performance has recently received more attention from a research perspective. For example, Murphy et al. (1988) found no strength improvements with the use of either fear or anger emotive imagery. Feltz and Riessinger (1990) paired performance feedback with emotive imagery which associated feelings of confidence and being "psyched-up". They found that the imagery increased the subjects perceived efficacy to endure isometric muscular performance. Although they found a significant effect on performance, they suggested that the results be considered cautiously as changes were less than the standard deviation.

Locus of Imagery Effect

A number of researchers have suggested that imagery may be functionally equivalent to actual experience. Finke (1979) found that errors of movement produced in mental imagery were functionally equivalent to physical errors of movement for changes in visual motor coordination. As well, Kohl and Roenker (1983) demonstrated bilateral transfer in the contralateral limb after training with mental imagery, while Johnson (1982) illustrated that imagery of movement could bias later motor performance the same way actual movement can bias motor reproduction. As a result, imagery has been suggested as an aid in the transfer of training to performance (Johnson, 1982; Kohl & Roenker, 1980, 1983).

Schmidt (1988) suggested that transfer was most commonly defined as "the gain (or loss) in the capability for responding in one task as a result of practice or experience on some other task" (p. 371). From the mental imagery perspective, this influence may be positive, negative, or neutral if imagery enhanced, harmed, or had no effect on the learning of a new skill. It has been suggested that the greatest amount of transfer will result when two tasks are similar in task components and performance conditions (Singer, 1980). The expectation, known as the specificity of learning hypothesis, is that if transfer is likely to occur, conditions during the acquisition trials need to be matched with those expected in the criterion test performance (Henry, 1968). Therefore, if mental imagery can create psychological conditions during training sessions similar to those during performance, and if, as Suinn (1983) suggested, a person experiences sensory-motor sensations that reintegrate reality experiences, then mental imagery could provide positive transfer from training to performance.

Studies by Shea and Morgan (1979) and Lee and Magill (1983) have contradicted the specificity of learning hypothesis. In these studies it was found that matching the conditions during the acquisition trials with those of the criterion test was not enough to provide for the most transfer. More critical in these studies was the similarity of the cognitive processes between the acquisition trials and the transfer trials. Morris, Bransford, and Franks (1977) termed this the concept of transfer appropriate processing. This concept "emphasizes that practice conditions that promote a particular type of processing during acquisition trials will facilitate transfer to the extent that these processing activities are also encouraged during the transfer trials" (Lee, 1988, p. 203). Therefore, positive transfer would result, according to the concept of transfer appropriate processing, if imagery during the training period utilized and developed the underlying cognitive processes required during the transfer test.

METHODOLOGICAL CONCERNS

Subject Characteristics

Most imagery studies have utilized non-elite or sub-elite athletes as subjects. As well, the subjects in the majority of these studies have been male and rarely included elderly or youth populations (Greenspan & Feltz, 1989; Howe, 1991). In particular, Greenspan and Feltz (1989) have suggested that these concerns limit the degree to which results can be generalized.

Design Characteristics

As a result of their 1983 review, Feltz and Landers suggested that researchers "redirect the research efforts of those in mental practice away from simply empirical demonstrations of mental practice effects on performance toward an examination of the variables that may moderate or mediate the relations between mental practice and motor performance" (p. 51). These feelings were echoed by several researchers who argued that this would allow a more detailed breakdown of the aspects of imagery that are successful (Greenspan & Feltz, 1989; Howe, 1991; Wollman, 1986). To accomplish this, Wollman, (1986) has suggested the use of more stringent control groups, the application of single subject designs, and a more effective evaluation of the quality and quantity of the imagery performed.

The use of control groups would allow for the isolation of the components contained within imagery routines to enpower researchers with the ability to determine more effectively the value of each component. Wollman (1986) suggested that more stringent control groups would allow researchers to determine the benefits of visual and kinesthetic imagery or to separate the advantages for the various cognitive, motivational or relaxational benefits of mental imagery. With the use of single subject designs, effects on motor performance would be more easily seen and program modifications could be made more conveniently. As well, this research design would be especially advantageous for studying special cases where a control-group (between-subjects) design would be impractical, such as with elite athletes. As well, Wollman (1986) advocated a more thorough monitoring of the internal experience to indicate the quantity and quality of imagery and the cognition and affect of subjects. Other writers have noted that the effect of imagery on non-targeted performance areas and follow-up assessments to determine the maintenance of imagery effects have rarely been completed. If this pattern of study was established, it would make possible the development of appropriate theory and the opportunity to critique existing models (Greenspan & Feltz, 1989; Howe, 1991).

Another concern in the imagery literature has been the inability of studies to determine whether the imagery variable affects learning or performance. Magill (1989) suggested that "performance can be thought of most simply as observable behavior" (p. 47) which, in terms of motor skills, would include activities such as shooting a basketball, running 100 meters, or kicking a soccer ball. Each of these behaviors could be observed and then measured. In contrast, learning has been defined as "a change in the capability of the individual to perform a skill that must be inferred from a relatively permanent improvement in performance as a result of practice or experience" (Magill, 1989, p. 48). As learning cannot be observed, it must be inferred from performance changes such as the increased performance of a skill or the increased consistency of the performance (Magill, 1989).

If imagery is a performance variable it would have an immediate effect on behavior which would dissipate when imagery is withdrawn, but if imagery affects learning the effect would be relatively permanent after the imagery is withdrawn. Van Gyn (1989) has suggested that to determine if imagery enhances performance it should be either paired with performance to see if performance improves, or it should be removed during performance to see if performance deteriorates. However, if imagery is to be considered a learning variable it is necessary to structure designs which will use a retention or transfer paradigm to determine if the performance change is due to learning (Magill, 1989; Van Gyn, 1989). To date, few imagery studies have been designed with a transfer or retention paradigm. Therefore it has been difficult to determine whether the imagery variable affects learning or performance. One study which established a transfer design for the study of mental imagery (Van Gyn et al., 1990) concluded that learning had occured after finding performance improvements in the 40 m sprint. In this study subjects, who paired imagery of the 40 m sprint with nonspecific training on a cycle ergometer, improved performance on the criterion test.

Hypotheses

To fulfill the purose of this study, the following hypotheses were tested:

Hypothesis 1: Those subjects who mentally imaged the on-ice skating sprint while performing peak power training on the cycle ergometer will have faster times during the on-ice skating sprint than subjects who performed the cycle ergometer training without mental imagery.

Hypothesis 2: Those subjects who performed peak power training on the cycle ergometer without mental imagery will have faster times during the on-ice skating sprint than subjects in a control group who did not train on the cycle ergometer or use mental imagery.

Hypothesis 3: Those subjects who participated in peak power training on the cycle ergometer will have higher peak power scores on the Wingate 30 s cycle ergometer test than those subjects who did not participate in peak power training on the cycle ergometer.

CHAPTER 3

METHODOLOGY

Selection of Subjects

Thirty six male ice hockey players volunteered to participate in this study. However, because of injury or absenteeism, the final sample included 32 subjects with a mean age of 24.4 years. Twenty two of the subjects played in the Victoria Senior Hockey League, while 10 subjects played in the intramural ice hockey league at the University of Victoria. Subject characteristics are presented in Table 1.

Independent Variable

The treatment conditions were a physical training (PT) group, a combined physical training and mental imagery (PTMI) group, and a control (CON) group.

The PT group performed a 6 week, 18 session, program on a Monark cycle ergometer designed to increase anaerobic alactic power. This program (see Appendix A) included a 2 min warm-up at 60 revolutions per min with a 1 kp resistance. Subjects then performed three sets of maximum intensity 10 s work intervals with resistance equal to .09 $g \cdot kg^{-1}$ body weight followed by 60 s of active recovery at the warm-up intensity. Inactive rest periods were used between the three sets. The program included progressions in workload every 2 weeks. During the program, resistance was set by trained assistants who also recorded revolutions during the work intervals (see Appendix B) and provided verbal encouragement for the subjects.

The PTMI group performed the same physical training program as the PT group. In addition these subjects performed two warm-up mental imagery exercises (see Appendix C)

Table 1

Means and Standard Deviations for the Physical Characteristics of the Subjects

Group	Age (years)	Weight (Kg)	Height (m)
PT	26.70 (4.22)	79.41 (9.82)	1.78 (0.08)
PTMI	25.18 (3.95)	74.63 (7.09)	1.73 (O.O6)
CON	24.55 (3.14)	83.65 (8.43)	1.77 (0.08)
TOTAL	25.44 (3.78)	79.23 (8.47)	1.76 (0.07)

Note. N = 32

which focused on specific daily imagery objectives (see Appendix D). Following the physical warm-up, the PTMI subjects utilized mental imagery of the on-ice skating sprint with standardized instructions (see Appendix E) each time they performed a work interval on the cycle ergometer. The mental imagery program focused on relaxation, skating technique, power association (see Appendix F), and pre-competition preparedness for the on-ice skating sprint. PTMI subjects were encouraged to attempt mental imagery exercises outside of the lab setting and exercises were provided to aid this practice (see Appendix G) based on exercises established for the Canadian Archery Team (Howe, McKenzie, Naylor, & Scott, 1989).

The CON group continued with their regular training. These subjects reported the extent of their physical training in daily exercise logs (see Appendix H) and were contacted every 2 weeks of the program to maintain their interest in finishing the study.

Dependent Variables

The dependent variables in this study were the times for the 60 ft and 120 ft on-ice skating sprint tests (60SS; 120SS) and an anaerobic alactic power score (AAP) from the Wingate 30 s cycle ergometer test.

The 60SS and 120SS were performed on artificial ice. Time to complete the required distance was measured to the nearest millisecond using Infrared Photocell Control Timers (Lafayette Model 63501 1R) located at the start line, 60 and 120 ft. Timers were set at a 2 ft height above the ice surface.

The Wingate 30 s cycle ergometer test was performed on a Monark 868 cycle ergometer equipped with a rev counter. The power output ($W \cdot kg^{-1}$) was calculated every 5 s (see Appendix I). The AAP score ($W \cdot kg^{-1}$) was the higher power output during the first two 5 s intervals.

Procedures

After subjects were recruited in December, 1989. An initial meeting was held to further detail all characteristics of the study, sign consent forms (see Appendix J), complete a Physical Activity Readiness Questionnaire (PAR-Q; see Appendix K) and to establish appropriate testing times.

All subjects were then required to complete the Wingate 30 s cycle ergometer test, 60SS, and 120SS (see Appendix L). On the basis of these tests, subjects were assigned to one of the three treatment conditions.

An initial meeting was conducted to introduce those subjects in the PTMI group to relaxation and imagery. During this session, the videotape entitled "Visualization: What You See Is What You Get" (Botterill, 1985) introduced the mental imagery technique and two practice exercises for relaxation and mental imagery were completed. All subjects were informed not to communicate any aspects of their mental training package to members of the other two treatment groups.

The PT and the PTMI groups then trained 3 times per week for 6 weeks while the CON group continued with their normal training. Upon completion of these programs all subjects performed post-tests on the Wingate 30 s cycle ergometer test, 60SS, and 120SS.

Instrumentation

1. Wingate 30 s Cycle Ergometer Test

The Wingate 30 s cycle ergometer test was completed on a Monark (Model 868) cycle ergometer equipped with a pedal frequency counter. The ergometer was calibrated before and after each testing session. Each subject performed a standardized 2 min warm-up with 1 Kp resistance at 60 revolutions per min pedal frequency. At the end of the warm-up, pedal frequency was increased to maximum as resistance was adjusted to 0.09 $g \cdot kg^{-1}$ body weight. The subjects exerted a maximum effort for 30 s and then continued to pedal slowly at a light resistance until they had recovered.

Power outputs ($W \cdot kg^{-1}$) were calculated for each 5 s interval during the test. Anaerobic Alactic Power (AAP) for each subject was determined using the highest power output ($W \cdot kg^{-1}$) during the first two 5 s intervals (protocol of the University of Victoria Sport and Fitness Center).

2. 60 and 120 Ft On-ice Skating Sprint Tests (60SS; 120SS)

All subjects completed a 5 min warm-up which included light stretching and skating. Subjects rested for 3 min after the warm up and then completed four maximum speed trials with 3 min rest between each trial. Each trial started from a stationary position 1 ft behind the start line. Skating time was measured in milliseconds with the fastest of the four trials recorded as the actual 60SS and 120SS scores (See Appendix M).

3. Daily Imagery Questionnaire

Three questions were selected from the Imagery Effectiveness Questionnaire (Albinson & Bull, 1988) which assessed the clarity, control, and quantity of mental imagery during imagery training (see Appendix N). The questionnaire was completed by each subject in the PTMI group after each imagery session, beginning with the third training session.

4. Follow-up Questionnaire

A questionnaire (see Appendix O), designed by the author, was administered to the PT and PTMI subjects to evaluate individual perceptions of the physical training program.

5. Logs

Subjects in the CON group completed daily logs in which they reported the amount of activity in which they were participating. The type, duration, and intensity of each activity was reported.

Limitations / Delimitations

1. Subjects exercise patterns outside of the testing and training sessions could not be controlled.

2. The Daily Imagery Questionnaire was not a validated instrument.

3. The 60SS and 120SS isolated specific closed skills and they were not necessarily related to hockey performance.

Data Analysis

A one-way ANOVA was administered to pre-test data for each variable to identify possible group differences. Post test scores for these variables were then analyzed with a one-way ANOVA and an F-max test was used to measure the homogeneity of variance. The significance level was set at $p<.05$. A one-way repeated measures ANOVA was completed on the Daily Imagery Questionnaire.

CHAPTER 4

RESULTS AND DISCUSSION

Descriptive Results

On-ice skating results for the 60SS and 120SS are presented in Table 2. The mean 60SS score for the entire sample was 3.078 s on the pre-test and 3.168 s during the post-test, while the mean 120SS score was 5.343 s on the pre-test and 5.421 s during the post-test. Means and standard deviations for all subjects with the exclusion of the goaltenders on the same variables are presented in Table 3. For this sample, the mean 60SS scores were 3.034 s and 3.119 s during the pre-test and post-test, respectively. While the mean 120SS scores were 5.260 s and 5.334 s for the pre and post-test. The goaltenders scores are displayed in Table 4. The results for the entire sample are slower than those demonstrated by the 1988 Canadian Olympic Team (Wenger et al., 1989) with skating times in this study at 3.00 s and 5.08 s over 60 and 120 feet respectively in August, 1986 and 2.88 s and 4.89 s over the same distances in November, 1986 after a combined physical and psychological training program.

The Wingate 30 s cycle ergometer test results prior to and following the 6 week training program are presented in Table 5. The mean AAP score for the all subjects was 10.41 $W \cdot kg^{-1}$ during the pre-test and 12.55 $W \cdot kg^{-1}$ after the training period. Based on a recent study by Maud and Shultz (1989), which established norms for the Wingate 30 s cycle ergometer test, these AAP post-test results are in the 95th percentile. As subjects were participants in the highly anaerobic sport of ice hockey (Fox, Bowers, & Foss, 1988) it would be expected for them to score high in an anaerobic test. The 1980 Canadian Olympic Hockey Team reported an AAP score of 11.7 $W \cdot kg^{-1}$ with a standard deviation of

Table 2

Descriptive statistics for all subjects on the 60SS and 120SS

		60SS		120SS	
Group	n	Pre-test	Post-test	Pre-test	Post-test
CON	11	3.104 (0.15)	3.168 (0.19)	5.352 (0.24)	5.409 (0.27)
PT	10	3.072 (0.25)	3.152 (0.25)	5.351 (0.45)	5.439 (0.42)
PTMI	11	3.059 (0.22)	3.178 (0.21)	5.328 (0.34)	5.415 (0.39)
TOTAL	32	3.078 (0.21)	3.168 (0.21)	5.343 (0.34)	5.421 (0.35)

Note. Means are recorded in milliseconds while standard deviations are in parentheses.

Table 3

Descriptive statistics for all subjects excluding goaltenders on the 60SS and 120SS

		60SS		120SS	
Group	n	Pre-test	Post-test	Pre-test	Post-test
CON	10	3.082 (0.14)	3.136 (0.17)	5.303 (0.19)	5.363 (0.24)
PT	9	3.002 (0.13)	3.090 (0.14)	5.220 (0.19)	5.317 (0.18)
PTMI	10	3.016 (0.18)	3.13 (0.14)	5.249 (0.23)	5.322 (0.25)
TOTAL	29	3.034 (0.15)	3.119 (0.15)	5.260 (0.20)	5.334 (0.23)

Note. Means are recorded in milliseconds while standard deviations are in parentheses.

Table 4

Descriptive statistics for goaltenders on the 60SS and 120SS

		60SS		120SS	
Group	n	Pre-test	Post-test	Pre-test	Post-test
CON	1	3.320	3.484	5.842	5.876
PT	1	3.701	3.780	6.533	6.541
PTMI	1	3.493	3.668	6.119	6.348
TOTAL	3	3.505 (0.19)	3.644 (0.15)	6.165 (0.35)	6.255 (0.34)

Note. Means are recorded in milliseconds while standard deviations are in parentheses.

Table 5

Means and standard deviations for all subjects on AAP during the Wingate 30 s Cycle Ergometer Test

Group	n	Pre-test	Post-test
CON	11	10.51 (1.16)	11.70 (0.92)
PT	10	10.36 (1.12)	13.05 (1.16)
PTMI	11	10.37 (1.01)	12.94 (1.09)
TOTAL	32	10.41 (1.07)	12.55 (1.20)

Note. AAP scores are presented in $W \cdot kg^{-1}$ while standard deviations are in parentheses.

0.20 for their sample of elite hockey players (Smith, Quinney, Steadward, Wenger, & Sexsmith, 1982).

However, it is difficult to compare studies as a variety of resistance settings have been used to optimize peak power outputs. For example, the norms established by Maud and Shultz (1989) were based on a resistance of .075 kp·kg body weight while the study by Smith et al. (1982) calculated a resistance based on body weight and leg volume. Evans and Quinney (1981) suggested that a higher resistance setting is necessary to optimize peak power outputs.

Studies can be compared when both studies used the same resistance. Therefore it may be more appropriate if results from this study are compared with results from the Canadian Olympic Hockey Team (Wenger et al., 1989) which used a resistance equal to 0.09 kp·kg body weight. Wenger et al. (1989) found AAP scores of 12.2 $W \cdot kg^{-1}$ and 12.9 $W \cdot kg^{-1}$ before and after a 12 week physical and psychological training program.

On-ice Skating Results

Pre-test scores for the 60SS and the 120SS were analyzed with a one-way ANOVA. There was no significant differences between the groups for the 60SS, $F(2,29) = .131$, $p>.05$, or for 120SS, $F(2,29) = .016$, $p>.05$. Tests for the homogeneity of variance were not significant.

Post-test results for the 60SS and the 120SS were analyzed with a one-way ANOVA. There was no significant differences between the groups for the 60SS, $F(2,29) = .018$, $p>.05$, or for the 120SS, $F(2,29) = .019$, $p>.05$. No support was found for hypothesis 1, which suggested that the PTMI group would be significantly faster in the 60SS and the 120SS than the PT group, or for hypothesis 2, which suggested that the PT group would be significantly faster on these skating sprints than the CON group. Tests for the homogeneity of variance for the 60SS and the 120SS were not significant.

This result contradicts findings from Van Gyn et al. (1990) and Wenger et al. (1989). Wenger et al. (1989) reported positive transfer from a combined off-ice physiological and psychological training program to an on-ice 60 ft skating test with the Canadian Olympic Hockey team. Improvement in sprinting performance was also reported in a study designed to enhance transfer with a mental imagery and cycle ergometer intervention (Van Gyn et al., 1990). However, the results support Steinbrink-Kelly (1989), who found no transfer from the combination of a mental imagery and rowing ergometer training program to performance on the water during rowing sprints.

Although no significant differences were evident between the groups on the pre-test or on the post-test scores for the 60SS or the 120SS, there was a change in skating times from the initial test to the final test. However, this change resulted from slower sprint times on the post-test for both the 60SS and the 120SS. Recognizing that the change in skating times was opposite to the anticipated direction of change, and that further analysis may provide spurious results, a t-test was performed to identify if the slower times from the post-test were significantly different than those of the pre-test on both the 60SS and the 120SS. The result was that $t(31) = 4.80$, $p<.001$ for the 60SS and that $t(31) = 4.13$, $p<.001$ for the 120SS.

The major reason for the increase in skating times from the pre-test to the post-test may have been the time of day for the final testing. The majority of skaters completed the pre-test for the 60SS and the 120SS between 6 p.m. and 9 p.m. while the post-test session was completed between 9 p.m. and 1 a.m.

Subjects may have been more fatigued, less motivated, and less aroused to perform the post-tests for the 60SS and the 120SS later in the evening. It has also been demonstrated that most physiological functions have specific times of the day when they are at a maximum level (Shephard, 1984; Winget, DeRoshia, & Holley, 1985) and that any athletic performance several hours before or after this peak would result in a performance which would be less than optimal. Winget et al. (1985) reviewed the effect of the time of day on major physiological variables and suggested that the optimal time for athletic performance was during the afternoon and early evening. Unfortunately, the exact involvement of the time of day on the post-test skating results cannot be assessed.

As reported, the PTMI group did not differ from the PT or CON groups on the 60SS and the 120SS. Further, all groups had slower times on the post-test for both the 60SS and the 120SS. In conclusion, this study does not show any support for the proposed (Van Gyn et al., 1990) use of mental imagery in combination with non-specific physical training to enhance the transfer of this training to an action performed in the typical sport environment.

Cycle Ergometer Results

Pre-test scores for AAP on the Wingate 30 s cycle ergometer test were analyzed using a one-way ANOVA. No significant differences were revealed between the groups, $F(2,29) = .065$, $p>.05$. A test for the homogeneity of variance was not significant.

On the post-test AAP scores, results from the one-way ANOVA indicated significant differences between the groups, $F(2,29) = 5.343$, $p<.01$. Post hoc comparisons utilizing the Tukey B method revealed AAP scores for the PTMI and PT groups that were statistically similar and these scores were significantly higher than the scores for the CON group. Hypothesis 3, which predicted subjects in the PT and PTMI groups, who performed the peak power training on the cycle ergometer, would achieve higher peak power scores (AAP) than the CON group who did not train on the cycle ergometer, was supported.

Based on the training principle of specificity (Henry, 1968; Singer, 1980) it was anticipated that those subjects who trained with 10s maximum sprints on the cycle ergometer would outperform those subjects without this training on a test measuring the highest power output over the first two 5 s intervals on this specific exercise in the Wingate 30 s cycle ergometer test. However, the actual AAP post-test scores for the PTMI and the PT groups were 13.05 $W \cdot kg^{-1}$ and 12.94 $W \cdot kg^{-1}$, which is similar to the results from the 1988 Canadian Olympic Hockey Team, which reported 12.9 $W \cdot kg^{-1}$ after a 12 week anaerobic training program (Wenger et al., 1989). At present, the Los Angeles Kings Hockey Club and the Canadian Olympic Hockey Team have set 13 $W \cdot kg^{-1}$ as a target for AAP (H. Wenger, personal communication, 1990). These results support the effectiveness of the cycle ergometer training program as it was able to promote peak power increases for the PTMI and PT over those for the CON group and achieve respectable scores following a 6 week program.

Daily Imagery Questionnaire Results

Daily Imagery Questionnaire means were calculated on each question for each imagery session to determine the improvement in the subjects' ability to use mental imagery. The results for Image Clarity, Image Control, and Image Quantity are presented in Figures 1, 2, and 3, respectively. These figures reported that the PTMI group were continually improving in image clarity, control, and quantity throughout their imagery program. Image clarity scores slowly improved from 6.05 during the 3rd session to 7.27 during the 8th session to 8.32 during the 17th session while image control scores improved from 5.14 to

Figure 1

Mean scores for all subjects in the PTMI group on Image Clarity

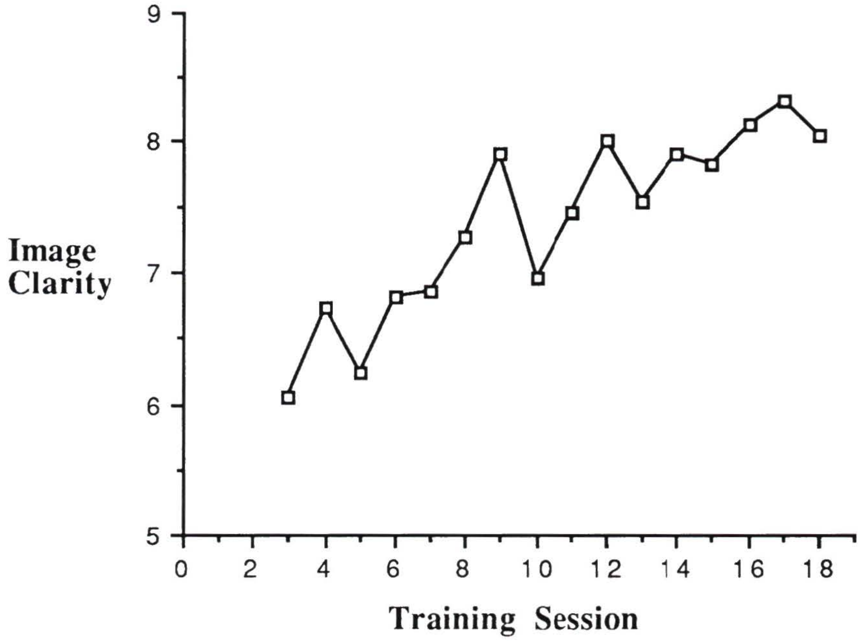


Figure 2

Mean scores for all subjects in the PTMI group on Image Control

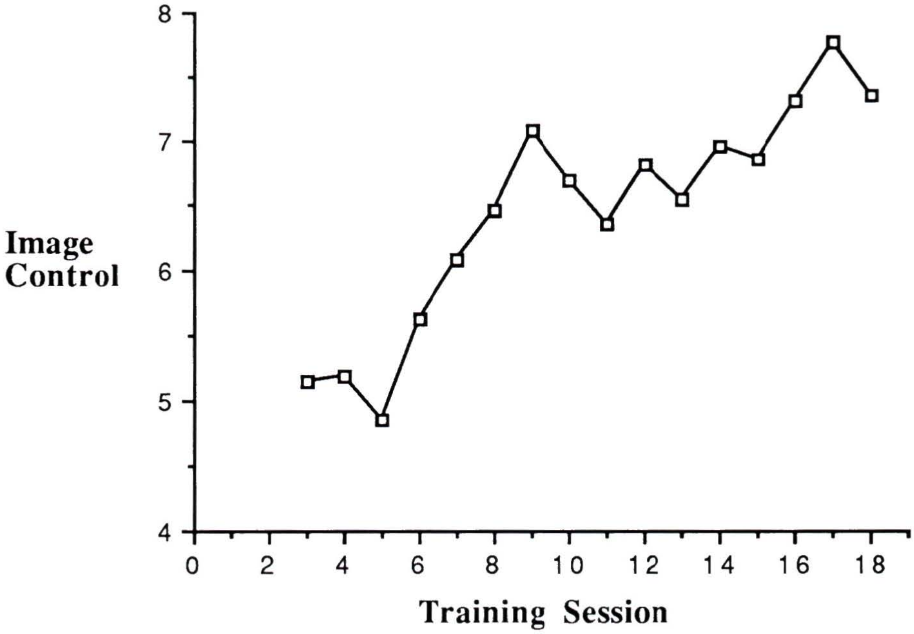
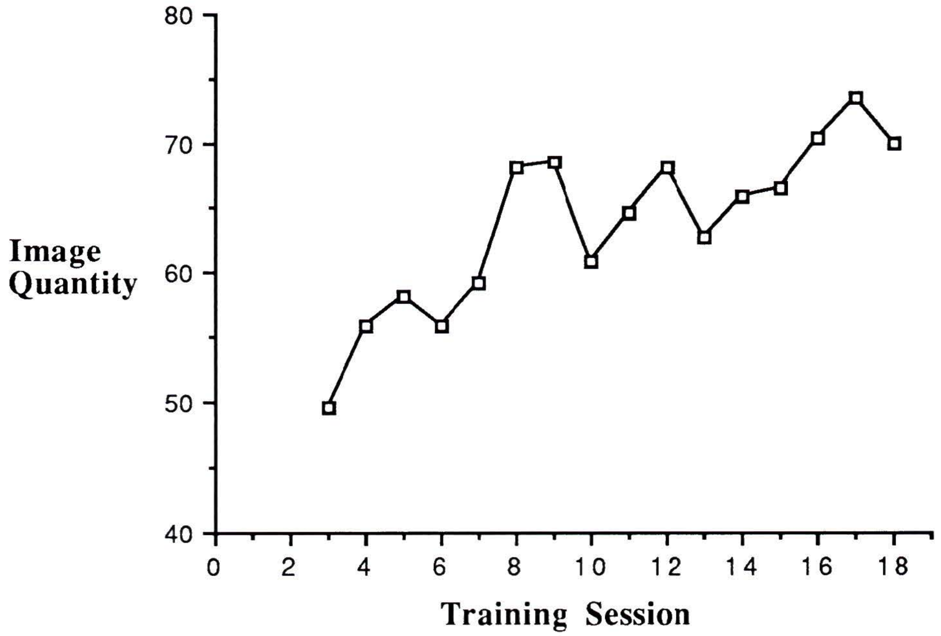


Figure 3

Mean scores for all subjects in the PTMI group on Image Quantity



6.46 to 7.77, and image quantity increased from 49.55 to 68.18 to 73.64 over the same sessions.

Daily Imagery Questionnaires were analyzed using a one way ANOVA with repeated measures design, and demonstrated a significant difference between the third and the eighteenth imagery session ($p<.01$) for image clarity, control, and quantity. As these results are based on subjective reports, caution is advocated in the interpretation of these results. However, from a visual analysis of figures 1, 2, and 3, the means for image clarity, control, and quantity tend to improve quickly from training session 3 until training session 9. Very little improvement is evident for image clarity, control, or quantity after the 9th training session. Because the PTMI group had nine training sessions before a levelling off of the improvement in imagery ability occurred, it is suggested that researchers and practitioners use caution in the application of mental imagery training programs without sufficient development time.

Richardson (1969) and Marks (1983) suggested that the ability to use imagery could be developed with appropriate training. Vealey (1986) recommended the need for repetitive practice to facilitate this improvement while Smith (1987) proposed that previous research with imagery may have been deficient in the quality and quantity of practice. Although the time required to develop effective images may vary a great deal across individuals, these results on the time required to develop effective images are supported by Vealey (1986) and Smith (1987) .

With the exception of the subject who was a goaltender, the PTMI group was separated into two groups with the five fastest players in the 60SS assigned to one group and the five slowest players assigned to a second group to determine if any differences existed in imagery ability between the two groups. Scores for image clarity, image control, and image quantity were analyzed with independent t-tests and results indicated no significant differences between the split groups on any of the measures. Although the sample was small, this study was not able to find support for the recognized assumption that individuals of greater ability levels are more effective imagers (Suinn,1983).

In addition to filling in a numerical response on the Daily Imagery Questionnaire, subjects were asked to add any comments to help describe their response to each question. Image clarity was rated on a scale from 1 (no image present. I just know I'm thinking of situation) to 11 (perfectly clear and strong just like actual thing) and the highest mean score for the group was 8.32 during the 17th session. The wording which corresponded to a nine on this scale suggested that the image was very clear, and compared to the sense of the real thing. All subjects reported that they saw the ice rink and felt as if they were skating, while fewer subjects reported that they heard noises as if they were skating.

All subjects reported that they benefitted from their use of a power word. A number of subjects reported that the power word helped them to prepare for the sprint and as they were able to concentrate harder, the clarity of their image improved. One subject reported, "I used the word 'burst' at the start and could see a flash of light as I left the line. This really helped me feel my start, and get a sense of power and speed. Best visuals yet!"

Subjects reported two major concerns with the clarity of their images. The first was a concern for the amount of cueing from the experimenter. Some subjects wanted to be talked through each sprint while other subjects wished only for key details to be announced as their image would be interrupted with information not necessary to them. The second concern related to image clarity was the duration of the cycle interval. Subjects were asked to cycle for 10 s at maximum effort while imaging the on-ice skating test and a typical player is able to get to the other end of the rink in 7 s.

The scale for image control in the Daily Imagery Questionnaire started at 1 (can with effort go from one picture to another) to 9 (can get smooth continuous image). The highest mean on image control for the PTMI group was 7.77.

The scale for image quantity was reported as a percentage of time imaging while on the cycle ergometer. The highest mean percentage was 73.64% during the 17th session. This score may appear low but many of the subjects found that with 1 min between trials on the cycle ergometer they would concentrate on breathing for the first 20 s after one repetition and then regain the image with 40 s remaining before the next sprint.

Cycle Ergometer Training Program Questionnaires

In this follow-up questionnaire, the subjects were asked to describe how they felt the training program had either positively or negatively affected their hockey. Although the subjects' perceptions of the personal benefits of the program were unanimously positive, many interesting responses were received. While 7 of the 21 subjects who performed the peak power training program reported they felt faster or that their acceleration had improved, 13 subjects reported that the program was beneficial because they were able to recover quicker between their shifts or they were able to achieve top speed later into the games when they would have been fatigued at those times before the program. One subject reported that "my legs don't feel as fatigued during games, especially in the third period" while another subject reported that he "improved mainly in recovery time after a shift."

Another response from 5 of the 21 subjects suggested that they felt more confident in their hockey ability. McKenzie (1989) also reported benefits to self confidence as a result of imagery training. Howe et al. (1990) proposed that mental imagery may be responsible for the improvement in the confidence levels of athletes in one of three ways. They suggested that confidence could have been improved as the imagery provided a medium in which the individual experienced successful performance, allowed the individual to receive a vicarious advantage after having watched another individual who successfully performed, or provided the individual with reinforcement and encouragement. Although no improvement in on-ice skating speed was demonstrated, it seems likely that coaches would be interested in training programs that could make some participants feel more self confident and have better recovery between shifts.

Subjects were also asked what made the training easier or more difficult for them. Of the 21 subjects performing the peak power training program, 13 responded that the encouragement and enthusiasm of the assistants made the program easier, while 7 suggested that the other subjects being present challenged them to keep going. These results are presented, since it was believed by the experimenter that they are the reason for the extremely low attrition rate during the study. One subject summarized a view held by many of the subjects that "the people helping were a lot of fun".

As well, it should be noted that seven of the subjects in the PTMI group reported that the imagery made the difficult cycling much more tolerable. This potential benefit for mental imagery during demanding physical training was supported with anecdotal evidence from the Canadian Olympic Hockey Team (C. Botterill, personal communication, 1991).

Conclusion

Although mental imagery has been suggested as an aid which could enhance the transfer of cycle ergometer training to on-ice skating speed, no support was found for this assumption. However, this study demonstrated support for the specificity of learning hypothesis as those subjects who trained on a cycle ergometer were significantly more powerful on their AAP scores than those subjects who did not train on cycle ergometers.

As well, the specificity of learning hypothesis would not have predicted any benefits for on-ice skating speed as a result of training on a cycle ergometer.

Many subjects reported benefits for their hockey performance from both the cycling program as well as the combined cycling and imagery program, although these data were not examined statistically because of the nature of this study. Subjects suggested benefits from the cycling training program that primarily focused on the decrease in the time needed to recover between shifts.

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APPENDIX A

Cycle Ergometer Training Program

CYCLE ERGOMETER TRAINING PROGRAM

Training sessions 1 to 6

Intensity	0.09 $g \cdot kg^{-1}$ body weight
Work Interval	10 s
Rest Interval	60 s
Repetitions	4
Sets	3
Rest Between Sets	5 min

Training sessions 7 to 12

Intensity	0.09 $g \cdot kg^{-1}$ body weight
Work Interval	10 s
Rest Interval	60 s
Repetitions	5
Sets	3
Rest Between Sets	6 min

Training sessions 13 to 18

Intensity	0.09 $g \cdot kg^{-1}$ body weight
Work Interval	10 s
Rest Interval	60 s
Repetitions	6
Sets	3
Rest Between Sets	7 min

APPENDIX B

Training Data Sheet

TRAINING DATA SHEET

Subject: ____________________

Regular Resistance: ____________________

Bike Number: ____________________

Bike Adjusted Resistance: ____________________

Time of Ride: ____________________

DATE__________

SET # 1
1. ____revs
2. ____revs
3. ____revs
4. ____revs
5. ____revs
6. ____revs

SET # 2
1. ____revs
2. ____revs
3. ____revs
4. ____revs
5. ____revs
6. ____revs

SET # 3
1. ____revs
2. ____revs
3. ____revs
4. ____revs
5. ____revs
6. ____revs

DATE__________

SET # 1
1. ____revs
2. ____revs
3. ____revs
4. ____revs
5. ____revs
6. ____revs

SET # 2
1. ____revs
2. ____revs
3. ____revs
4. ____revs
5. ____revs
6. ____revs

SET # 3
1. ____revs
2. ____revs
3. ____revs
4. ____revs
5. ____revs
6. ____revs

DATE__________

SET #1
1. ____revs
2. ____revs
3. ____revs
4. ____revs
5. ____revs
6. ____revs

SET #2
1. ____revs
2. ____revs
3. ____revs
4. ____revs
5. ____revs
6. ____revs

SET # 3
1. ____revs
2. ____revs
3. ____revs
4. ____revs
5. ____revs
6. ____revs

APPENDIX C

Daily Imagery Exercises

DAILY IMAGERY EXERCISES

Before the subjects in the PTMI group started their physical warm-up on the bicycles they performed two mental imagery exercises. These exercises were completed to continually challenge the subjects ability to image clearly and to control their image. It was attempted to make these exercises more difficult as the program developed by moving from a specific aspect of the skate to a more complete image. These exercises also allowed an opportunity to give specific challenges with regard to the subjects' visual, kinesthetic, and auditory representations of the action. An example aimed at developing a kinesthetic sense for the explosive start follows.

> Listen to the following activity and when you feel comfortable and ready then attempt it. When you are relaxed and comfortable, I would like you to put yourself on the ice sitting on the bench at the far end of the rink waiting for your turn to skate. This time when you skate down the ice I would like you to pay close attention to the feeling in your legs as you explode from the goalline feeling the lean of your body as you accelerate. Feel your muscles as they exert force against the ice with powerful short strides as you accelerate. Be aware for the things your body feels as you skate down the ice. On your own time go through your skate paying close attention to the feelings in your body.

APPENDIX D

Imagery Training Schedule

IMAGERY TRAINING SCHEDULE

INTRO IMAGERY SESSION:	-breathing and relaxation exercises -image arena -image on-ice skating sprint
TRAINING SESSION #1 to #6:	-develop relaxation -improve ability to image skate from all senses -concentrate image on the start and increasing stride as speed increases
TRAINING SESSION #7 to #12:	-continue relaxation -continue with skill emphasis on internal image -adopt power words to enhance concentration
TRAINING SESSION #13 to #18:	-continue relaxation -continue to improve image of skating action -continue with the use of power words -add pre-competition information

APPENDIX E

Mental Imagery Instructions

MENTAL IMAGERY INSTRUCTIONS

A set of instructions were given to the subjects in the PTMI group prior to each interval on the cycle ergometer. This image tried to recreate those aspects associated with the 60SS and 120SS.

With 60 s between each repetition it was necessary to state the time remaining before the next repetition at regular intervals so subjects were ready to start at the exact time. When the time was stated subjects were given verbal instructions for their imagery. Subjects were asked to attempt to improve their image quality with each trial by adding to the characteristics they saw, felt, and heard.

40 seconds	Get yourself comfortable-concentrate on your breathing
30 seconds	When ready start moving over the ice, gently one leg goes to push easily and then the other.
20 seconds	See yourself moving towards the goalline, when you skate this time think about and feel the action in your body as you lean into your explosive start and continue the length of the ice.
10 seconds	See yourself getting ready to start-feel the power
5 seconds	4 3 2 1 SKATE!

APPENDIX F

Power Script

POWER SCRIPT

In an attempt to make the imagery experience as much like the actual experience as possible a number of words were selected which promoted the feeling of power that is necessary in the 60SS and 120SS. Subjects selected a word from the following list or identified one of their own that brought the feeling of being powerful to them as they skated from the goalline at full speed.

bang	explode	leap	quick
blast	explosive	might	rip
boom	flick	pistons	skate
carve	fling	pop	snap
cut	force	power	stride
dash	impel	pull	sunburst
drive	jump	push	thrust

APPENDIX G

Mental Imagery Exercises

MENTAL IMAGERY EXERCISES

These exercises were designed to help you improve your ability to image. The first three exercises focus on the clearness or vividness of your image based on your senses (feeling, seeing, hearing, and to a lesser extent tasting and smelling). The second three exercises focus on developing the ability to control your image. The third exercise in each section is specific to the on-ice skating task we perform while on the bicycle.

Remember, it is important to be relaxed yet alert when rehearsing these exercises. It may be beneficial to get to get into a comfortable place where it will be quiet so you will have less distractions.

VIVIDNESS

1. Pick a friend and imagine them standing in front of you. Try to get a sharp image of that person (body build, facial features, clothes, etc.).

   -Now imagine the person talking. While still seeing the person's face try to hear the person's voice. Try to imagine all their facial expressions as they talk.

   -Try to create the emotions that you feel toward this person (friendship, admiration, respect, etc.).

2. See yourself standing at center ice by yourself. Notice the quiet emptiness and try to pick out as many details as you can.

-Now imagine yourself in the same setting but this time with a goaltender in the net as you prepare to take a penalty shot. Notice the officials, teammates, and spectators as you prepare. Focus on the sights sounds and feels as you are getting ready.

-Now imagine yourself in the same setting and see yourself shoot a number of penalty shots trying to feel the different moves you make on the goalie as you score.

3. Now see yourself sitting on the bench (behind the goalline) as you did in the on-ice skating test. Notice as much detail as possible.

-Now imagine my assistant taking your heart rate as you prepare for your skate.

-Now there is thirty seconds left before you skate so stand up and skate easily around behind the goalline. Try to create this feeling of what it will be like.

-Now imagine yourself coming to a stop between the pylons and then exploding down the length of the ice. Try to recreate what you feel (think about the different parts of the body and the angle or lean of the body), see, and hear as you skate. **note - it may be easier to concentrate on one thing the first time you go through this and then add to it each time with other sensations.

CONTROL

1. Imagine again the first person you selected for the first exercise in vividness. Concentrate on their face and notice all the different features.

   -Now imagine the person walking around a room full of people. Watch the person walk around the room greeting and talking to different people.

2. Choose a particular aspect of your game that you have been having trouble performing. Recreate the experience in which you have not performed the skill well. Take careful notice of what you are doing wrong.

   Now imagine yourself performing the skill correctly. Focus on how your body feels as you go through the actions of performing the skill correctly.

3. Imagine yourself preparing for the on-ice sprint as you did earlier. This time I want you to control the feeling of power in your legs before you explode from the line

   -Imagine the person taking your heart rate this time. This time have the person start a short conversation with you. Now get yourself ready for your skate and then perform it as you have done before.

APPENDIX H

Daily Exercise Logs

DAILY EXERCISE LOGS

Please include the daily activities or exercises you perform and the length of time you are active during the study. There is no need for you to change your exercise patterns. I will collect these logs from you before your final testing in 6 weeks time.

MONDAY, JANUARY, 15th ____________________

____

TUESDAY, JANUARY, 16th ____________________

____

WEDNESDAY, JANUARY, 17th ____________________

____

THURSDAY, JANUARY, 18th ____________________

____

FRIDAY, JANUARY, 19th ____________________

____

SATURDAY, JANUARY, 20th ____________________

____

SUNDAY, JANUARY, 21st ____________________

____

APPENDIX I

Wingate 30 s Cycle Ergometer Test

Data Sheet

DATA SHEET

WINGATE 30 s CYCLE ERGOMETER TEST

SUBJECT: ____________________________

AGE: ____________________________

DATE: ____________________________

WEIGHT ____________________________

RESISTANCE ____________________________

P.O. @ 5 s ________revs ________Watts ________Watts / kg

P.O. @ 10 s ________revs ________Watts ________Watts / kg

P.O. @ 15 s ________revs ________Watts ________Watts / kg

P.O. @ 20 s ________revs ________Watts ________Watts / kg

P.O. @ 25 s ________revs ________Watts ________Watts / kg

P.O. @ 30 s ________revs ________Watts ________Watts / kg

Anaerobic Alactic Power (Absolute) =________________ Watts

Anaerobic Alactic Power (Relative) =________________ $W \cdot kg^{-1}$

Anaerobic Alactic Capacity =________________ Joules

Anaerobic Lactic Power (Absolute) =________________ Watts

Anaerobic Lactic Power (Relative) =________________ $W \cdot kg^{-1}$

Anaerobic Lactic Capacity =________________ Joules

APPENDIX J

Informed Consent

INFORMED CONSENT

As part of my Masters degree program at the University of Victoria I am conducting research into training procedures for ice hockey. In particular the research will examine the various ways to use a bicycle ergometer to improve on-ice hockey speed.

For this study I need 36 subjects to participate three times per week in a six week training program on stationary bicycles. The volunteers will be asked to perform a laboratory test and an on-ice skating test at the start and at the end of the training program.

This letter is to ask for your consent to participate in this study. As a volunteer in this study you would have the right to withdraw at any time. You are assured that the data collected will remain totally confidential. If you have any questions please do not hesitate to call me.

Sincerely Yours,

George Kelly

I,______________________________ , hereby give my informed consent to participate in this study and understand that I may withdraw at any time.

APPENDIX K

Physical Activity Readiness Questionnaire

APPENDIX 4

PARTICIPANT IDENTIFICATION

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)*
A Self-administered Questionnaire for Adults

PAR Q & YOU

PAR-Q is designed to help you help yourself. Many health benefits are associated with regular exercise, and the completion of PAR-Q is a sensible first step to take if you are planning to increase the amount of physical activity in your life.

For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and check the ☑ YES or NO opposite the question if it applies to you.

YES NO

☐ ☐ 1. Has your doctor ever said you have heart trouble?

☐ ☐ 2. Do you frequently have pains in your heart and chest?

☐ ☐ 3. Do you often feel faint or have spells of severe dizziness?

☐ ☐ 4. Has a doctor ever said your blood pressure was too high?

☐ ☐ 5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?

☐ ☐ 6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?

☐ ☐ 7. Are you over age 65 and not accustomed to vigorous exercise?

If You Answered

YES to one or more questions

If you have not recently done so, consult with your personal physician by telephone or in person BEFORE increasing your physical activity and/or taking a fitness test. Tell him what questions you answered YES on PAR-Q, or show him your copy.

programs

After medical evaluation, seek advice from your physician as to your suitability for:

- unrestricted physical activity, probably on a gradually increasing basis.
- restricted or supervised activity to meet your specific needs, at least on an initial basis. Check in your community for special programs or services.

NO to all questions

If you answered PAR-Q accurately, you have reasonable assurance of your present suitability for:

- A GRADUATED EXERCISE PROGRAM - A gradual increase in proper exercise promotes good fitness development while minimizing or eliminating discomfort.
- AN EXERCISE TEST - Simple tests of fitness (such as the Canadian Home Fitness Test) or more complex types may be undertaken if you so desire.

postpone

If you have a temporary minor illness, such as a common cold.

* Developed by the British Columbia Ministry of Health. Conceptualized and critiqued by the Multidisciplinary Advisory Board on Exercise (MABE). Translation, reproduction and use in its entirety is encouraged. Modifications by written permission only. Not to be used for commercial advertising in order to solicit business from the public.
Reference: PAR-Q Validation Report, British Columbia Ministry of Health, May, 1978.

* Produced by the British Columbia Ministry of Health and the Department of National Health & Welfare.

APPENDIX L

Training and Testing Schedule

SCHEDULE OF TRAINING AND TESTING SESSIONS

JANUARY 3rd and 6th	ON-ICE TESTING
JANUARY 8th and 11th	WINGATE TESTING
JANUARY 15th	IMAGERY INTRODUCTION MEETING
JANUARY 17th	TRAINING SESSION # 1
JANUARY 19th	TRAINING SESSION # 2
JANUARY 22nd	TRAINING SESSION # 3
JANUARY 24th	TRAINING SESSION # 4
JANUARY 26th	TRAINING SESSION # 5
JANUARY 29th	TRAINING SESSION # 6
JANUARY 31st	TRAINING SESSION # 7
FEBRUARY 2nd	TRAINING SESSION # 8
FEBRUARY 5th	TRAINING SESSION # 9
FEBRUARY 7th	TRAINING SESSION # 10
FEBRUARY 9th	TRAINING SESSION # 11
FEBRUARY 12th	TRAINING SESSION # 12
FEBRUARY 14th	TRAINING SESSION # 13
FEBRUARY 16th	TRAINING SESSION # 14
FEBRUARY 19th	TRAINING SESSION # 15
FEBRUARY 21st	TRAINING SESSION # 16
FEBRUARY 23rd	TRAINING SESSION # 17
FEBRUARY 25th	TRAINING SESSION # 18
MARCH 2nd	ON-ICE TESTING
MARCH 5th	WINGATE TESTING

APPENDIX M

60SS and 120SS Data Sheet

DATA SHEET

ICE SKATING VELOCITY TEST

SUBJECT: ____________________________

AGE: ____________________________

DATE: ____________________________

RINK: ____________________________

TRIAL #	60SS	120SS
1	_______	________
2	_______	________
3	_______	________
4	_______	________
BEST TIME	_______	________

Note. It is not necessary that the best times for the 60SS and 120SS be from the same trial.

APPENDIX N

Daily Imagery Questionnaire

DAILY IMAGERY QUESTIONNAIRE

Name: ______________________

Date: ______________________

INSTRUCTIONS

Please, fill in the following three scales based on your ability to image in today's training session.

Clarity

No image present. I just know I am thinking of situation... 1
2
Very vague and dim. Can hardly make it out................ 3
4
Vague and dim but aware of what it is......................... 5
6
Moderately clear and distinct.................................... 7
8
Very clear, comparable to sense experience of real thing..... 9
10
Perfectly clear and strong, just like actual thing.............. 11

Ability to Manipulate

Can with effort change from one image to another........... 1
2
Can easily get one image at a time.............................. 3
4
Can get a series of snapshots.................................. 5
6
Can get jerky movements....................................... 7
8
Can get smooth continuous movements........................ 9

Imagery Quantity

While you were on the bicycle what percent of the time were you able to maintain the image on which you were attempting to focus or concentrate.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

APPENDIX O

Follow-up Questionnaire

FOLLOW UP QUESTIONNAIRE

1. How has the biking program affected your hockey?

____

____

2. Has the biking program helped in any other activities in which you participate?

____

____

3. How difficult was the physical training?

   First 2 Weeks ______________________

   Second 2 Weeks ______________________

   Third 2 Weeks ______________________

4. What things made the training easier for you?

____

____

5. What things made the physical training more difficult for you?

____

____

VITA

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Title of Thesis: The Effect of Imagery on the Transfer of Cycle Ergometer Training to On-ice Skating Speed

Author: [redacted]

GEORGE PETER KELLY

September 26, 1991