An Integrated Biofeedback and Psychological Skills Training Program for Canada’s Olympic Short-Track Speedskating Team

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The present article outlines the development and implementation of a multifaceted psychological skills training program for the Canadian National Short Track Speedskating team over a 3-year period leading up to the Vancouver 2010 Olympic Games. A program approach was used emphasizing a seven-phase model in an effort to enhance sport performance (Thomas, 1990) in which psychological skills training was integrated with biofeedback training to optimize self-regulation for performance on demand and under pressure. The biofeedback training protocols were adapted from general guidelines described by Wilson, Peper, and Moss (2006) who built on the work of DeMichelis (2007) and the “Mind Room” program approach for enhancing athletic performance. The goal of the program was to prepare the athletes for their best performance under the pressure of the Olympic Games. While causation cannot be implied due to the lack of a control group, the team demonstrated success on both team and individual levels.

Keywords: biofeedback, sport, performance enhancement, speedskating, Olympic

The effectiveness of psychological skills training (PST) on performance has been suggested in previous sport psychology reviews (e.g., Gould & Eklund, 2007; Hardy, Jones & Gould, 1996; Landers, 1995; Vealey, 1988, 2007; Weinberg & Comar, 1994). Sport psychologists must interpret the results of these studies

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with caution, however. This is especially true for those working with elite athletes, as very few PST research studies have involved interventions with elite athletes (Greenspan & Feltz, 1989). In this regard, previous discussions of methodological issues have noted five possible reasons for weak effect sizes of mental skills training interventions (Landers, 1995; Nitsch, 1997; Tenenbaum & Bar-Eli, 1995; Vealey, 1994; Weinberg & Comar, 1994), including (a) the use of nonathletic participants in laboratory settings rather than elite athletes engaged in sport specific contexts; (b) considerations of idiographic and nomothetic designs; (c) selection of potentially beneficial treatment applications to specific populations, regardless of ethical considerations; (d) rarity of specific measurement tools other than self-report to measure psychological responses to pressure; and (e) the short length of interventions, which may preclude important on-going appraisals while ignoring nontargeted areas over time.

Within sport psychology practice, there is some interest in the implementation of PST as a critical component within the yearly training plans of national team programs (Weinberg & Gould, 2010). The intended purpose of these PST programs is to provide athletes and teams with the skills and strategies to overcome cognitive and emotional barriers, in the service of achieving their goals (Blumenstein, Lidor & Tenenbaum, 2005). Vealey (2007), in her review of PST programs, has suggested three areas for the development of PST interventions: (a) the need for sport specific PST programs whereby psychological practice is incorporated with physical training, (b) emphasis on teaching athletes how to set individualized competition plans for their sport, and (c) the need for a process approach within the PST program. In addition, a number of sport psychologists have suggested that packaging or grouping of psychological strategies into a program approach may be useful when working with individual and or team sports (Boutcher & Rotella, 1987; Hardy, Jones, & Gould, 1996; Vealey & Greenleaf, 2006). Thomas’s (1990) seven-phase closed-loop process model reflects one general approach in the sport psychology domain (Gould & Eklund, 2007). From an applied perspective, many variables can affect the process of a PST program; however, this transactional model (Bar-Eli, 2002) appears to provide a useful overall framework for the implementation of an integrated PST program approach.

The integration of a PST program approach typically includes a combination of psychological skills training techniques with the specific needs of the athlete, taking into consideration factors such as age, gender, years and level of experience, the specific demands of the sport (technical, tactical, physical, and mental), and the environmental demands of the sport (Balague, 2000). Previous research in the area of periodization training leading to elite athletic performance through the utilization of quadrennial and yearly training plans (YTP) has made a contribution to the art and science of YTP’s (Bompa, 1983; Smith, 2003). Recently, several researchers have proposed an integrated periodized PST program over consecutive training cycles whereby education, skill acquisition, and implementation of skills allow for long-term development while directly reflecting individual needs and differences (Balague, 2000; Fournier, Calmels, Durand-Bush, & Salmela, 2005; Holliday et al., 2008; Lidor, Blumenstein, & Tenenbaum, 2007).

According to Schwartz (1979), self-regulation is an integral part of mental assessment and/or intervention activities used to facilitate athletic performance (Crews, 1993; Crews, Lochbaum, & Karoly, 2001; Hatfield & Hillman, 2001; Kirschenbaum, 1984; Zaichkowsky, 1983; Zaichkowsky & Fuchs, 1988, 1989).
Historically, sport psychology researchers (Blumenstein, Bar-Eli, & Tenenbaum, 1995, 2002; Hatfield & Landers, 1983; Landers, 1985) have suggested that psychophysiological assessment of athletes would allow sport psychologists to objectify assessments beyond that of self-report questionnaires. In the past, psychophysiology in general, and biofeedback in particular, have been used primarily in laboratory settings (Andreassi, 2000). More recently, however, with the advent of telemetry and portable devices, biofeedback with athletes has gained more ecological validity within a transactional framework in sport psychology interventions (Bar Eli, 2002).

The ultimate goal of all PST programs is to render the athletes autonomous and effectively functioning without the direction of the coach or sport psychologist (Weinberg & Gould, 2010). Preliminary research has shown that biofeedback may possibly enhance the effectiveness of PST programs to improve self-regulation in the face of competitive and noncompetitive demands (Blumenstein, Bar-Eli, & Tenenbaum, 2002). For example, a study by Bar-Eli and Blumenstein (2004) found that biofeedback in combination with mental skills training resulted in better performance compared with relaxation training alone in preelite swimmers. Some form of biofeedback or nonintervention based physiological measurement has been used in other sports such as archery (Filho, Moraes, & Tenenbaum, 2008; Salazar et al., 1990), basketball (Kavussanu, Crews, & Gill, 1998), baseball (Strack, 2003), target shooting (Daniels & Landers, 1981; Deeny, Hillman, Janelle, & Hatfield, 2003; Hatfield, Landers, & Ray, 1987), golf (Boutcher & Zinsser, 1990; Crews, 1991; Crews & Landers, 1993; Kirschenbaum, Owens, & O’Connor, 1998), combat sports (Blumenstein, 1999) and gymnastics (Peper & Schmid, 1983; Shaw, 2010; Zaichkowsky, 1983). Among the specific empirical studies, however, methodological limitations, such as lack of control groups and use of subjective reports for performance evaluations, ultimately preclude definitive conclusions regarding the effectiveness of biofeedback in sport.

The Current Study: Integrated Three-Year PST and Biofeedback Program

The purpose of the present article is to report on the integrated PST program that was designed and implemented with the Canadian National Short Track Speedskating Team over a 3-year period in preparation for the 2010 Vancouver Olympic Games. A program approach was used emphasizing a seven-phase model for performance enhancement (Thomas, 1990) in which PST was integrated with biofeedback training in an effort to optimize self-regulation for performance on demand and under the pressure (Blumenstein, 1999; Blumenstein & Bar-Eli, 2001; Blumenstein, Bar-Eli & Tenenbaum, 2002) of the Olympic Games.

Method

Participants

Participants consisted of 10 male and 10 female athletes ($N = 20$) recruited from Speedskating Canada at the National Training Center in Montreal, Canada who were designated as part of the development or national team based on performance results at National Trials held three times each year. As a requirement for
participation at the National Training Center, a consent form was signed by each athlete volunteering for all sport science research. Once consent was obtained to participate, the program proceeded at Canada’s National Speedskating Training Center “Mind Room” (Wilson, Peper, & Moss, 2006) designed for performance enhancement for the time period of 2007–2010.

**Description of the Intervention**

**Phase 1: Orientation/Observation.** The uncontrolled intervention program was periodized over 3 years with the Speedskating Canada yearly training plan (YTP). The integrated program approach adapted from Thomas’s (1990) process model was proposed to the coaches and high performance director (HPD) as a methodology that could potentially achieve the goals of the performance enhancement program. In September of year 1, the HPD and coaches shared their YTP and asked what type of mental training activities would be administered in year 1 of the program. It was preferable to complete the first three phases of the program (i.e., observation, qualitative assessment, and quantitative assessment), however, before making a commitment to an intervention strategy without having accurate data upon which to implement an intervention. A model for the 3-year program is illustrated in Figure 1. Subsequently, meetings with HPD, coaches, and one-on-one consultations with athletes provided important qualitative information.

**Phase 2: Sport Analysis.** In this phase, observations made at National Trials revealed the complexity of preparation for (a) off-ice prerace warm-ups, (b) daily training programs, (c) waiting times in the heat box before competition, (d) the number of races required to be in the finals, and (e) the selection of the World Cup Team that would compete internationally for the next several months. Structured monthly meetings and informal meetings with the integrated support team (IST; e.g., medical doctor, nutritionist, physiologist, biomechanics, strength, physiotherapist, equipment technician) were effective in terms of understanding IST program interventions, triangulating data, and developing monthly data sheets on each athlete for coaches. This phase allowed the consultant to understand both the culture of speedskating and also the terms of reference used in this sport.

**Phase 3: Individual and Team Assessment.** Qualitative and quantitative assessment highlighted the psychological strengths and areas for improvement based on both an individual profile and an overall team profile. Specifically, mental skills assessment included qualitative interviews and administration of the Ottawa Mental Skills Assessment (Durand-Bush, Salmela, & Green-Demers, 2001). The key question was this: Which areas need to be improved? Interviewing the coaches in this phase was also critical to obtaining their support for the program approach. The goal for the first year was to conduct a complete mental skills training program for the development team and a prioritized program for the men’s and women’s National Teams based on the assessments in phase 3.

**Phase 4: Concept Utilization.** The qualitative and quantitative data collection revealed that athletes’ mental skills and responses to stress were the two major areas to target. Thus, it was decided to focus on (a) mental skills education in the first year of the program, (b) self-regulation skills in the second year of the program, and (c) individualization of competition-specific interventions in the third
3-Year Speedskating Approach

![Integrated Three-Year Sport Psychology Performance Enhancement Program](image)

**Figure 1** — The seven phases of the 3-year integrated program (adapted from Thomas, 1990).

To achieve the mental skills goal in year 1, we decided to produce a mental skills workbook individualized for short track speedskating. The initial communication tool was educational seminars, while follow-up individual consultations were used to help athletes individualize the utilization of mental skills. A companion mental skills training log book was used to aid athletes in transferring their psychological skills into their daily training. Finally, having been presented with the YTP by the coaches, the sport psychology consultant was able to schedule the mental skills training within the training program. This process helped ensure that the program was integrated as part of a comprehensive training program; sessions were scheduled at specific times and days in a preselected room on a weekly and monthly basis and not as an add-on after training.
Phase 5: PST Intervention Strategies. In this phase, the sport psychologist in concert with the coaches selected the content of the psychological skills program (PST) that would be introduced to the athletes. The PST program was presented in three phases (Meichenbaum, 1985): (a) educational phase, (b) acquisition stage, and (c) practice stage. This process ensured that the PST program would help athletes internalize the content from the cognitive-behavioral mental skills workbook and then apply it daily through the use of their training log books.

Phase 6: Implementation. In this phase, the sport psychology consultant implemented the interventions designed to achieve the goals set in the first year of the program. It should be noted that key to the success of the intervention is the cooperation of the coaches. To this end, it is imperative to develop positive relationships and an understanding with coaches to help ensure a team mindset. Obstacles or barriers to implementing such interventions need to be identified and dealt with before one begins the implementation process.

Phase 7: Evaluation. Evaluation was an on-going process to ensure compliance with the program among the athletes. The leadership of the coaches was a major factor relative to the success of monitoring log book utilization and attendance at the seminars. In addition, quantitative assessments were built into the integrative program approach to evaluate the level of success for each of the interventions that were implemented. This process builds accountability into the program. Budgets for the following year, purchase orders for capital equipment, and objectives for year 2 were articulated and planned for at this time. In addition, at the end of each season, performance graphs were developed to illustrate the strengths and successes of each athlete relative to his or her World Cup competitors. These graphic performance statistics were also part of the individual athlete profiles that allowed the HPD and coaches to visually observe the trends in performance and identify new areas of concern. Consequently, gap analysis, goals, and action plans (e.g., tactical, technical, physical, mental) could be individually set with each athlete for the following year and compiled into their athlete performance profiles.

Assessment Tools

Qualitative Interviews. The semistructured interview protocol was based on previous research (Goss & Beauchamp, 1994) that had been adapted from the qualitative literature (Gould, Eklund, & Jackson, 1992, 1993). Themes of the interview protocol included psychological skills for peak performance (e.g., motivation, confidence, arousal, imagery, focus, relaxation), best and worst competitions, mental preparation strategies, deliberate and quality training, daily routines, distraction control, precompetition plans, competition plans, refocus plans, competition evaluation plans, mental readiness and individual zone of optimal performance (IZOP), stress coping, and rest and recovery strategies.

Ottawa Mental Skills Assessment Test (OMSAT-3). The third version of the Ottawa Mental Skills Assessment Test (OMSAT-3) was used at the beginning of years 1, 2, and 3 to measure critical mental skills relevant to sport performance, as reported by the athletes (Durand-Bush, Salmela, & Green-Demers, 2001). Each item is answered on a 7-point Likert scale ranging from 1 (strongly disagree) to 7
(strongly agree), with a neutral choice available. The OMSAT-3 classifies mental skills into three main components: foundation skills (e.g., goal-setting, confidence, commitment), psychosomatic skills (e.g., stress and fear reactions, relaxation, activation), and cognitive skills (e.g., focus, refocusing, imagery, mental practice, competition planning).

**Recovery-Stress Questionnaire (RESTQ-Sport).** The athletes completed the RESTQ-S to monitor their rest and recovery profiles (Kellmann & Kallus, 2001). The RESTQ-S was introduced at the end of year 1 and subsequently used every month in years 2 and 3 to coincide with blood samples and performance times so that the IST team could triangulate the data for coaches. The RESTQ-S is a 76-item questionnaire designed to assess the physical and mental impact of training stress and to facilitate the formulation of strategies for the enhancement of recovery. It consists of 12 general stress and recovery scales along with seven sport-specific stress and recovery scales. Subjects were instructed to respond to each item on a self-rated 7-point Likert scale ranging from 0 (never) to 6 (always) according to how well the item was deemed to be self-descriptive for the previous 3 days and nights. Recent empirical evidence suggests that the tool can be used to provide a valid reflection of changes in training stress and to predict an overall change in sport performance testing (Villanueva, Bennett, Gilbert, & Schroeder, 2010). The RESTQ-S was initially developed based on the hypothesis that an accumulation of stress in different areas of life, with insufficient opportunity for recovery, can potentially lead to a compromised psychophysical state (Kellmann & Kallus, 2001). Internal consistency of the questionnaire, test-retest reliability, and validity for measuring general parameters of training stress have all been demonstrated (Kellmann & Kallus, 2001; Davis, Orzech, & Keelan, 2007).

To monitor and better understand the data from each athlete, qualitative data were also gathered from each athlete on what rest, recovery, and regeneration activities the athletes were utilizing. These data were gathered via a structured interview schedule and tabulated in a table for each athlete. In addition, during the summer training camp preceding the Olympic Games, the athletes took part in educational seminars during the 3-week summer training camp on the importance of rest, recovery and regeneration, sleep quality, media training, family and friends planning, and maintaining focus in preparation for the 2010 Olympic Games journey.

**Competitive State Anxiety Inventory-2 (CSAI-2).** The night before the first day of selected key competitions in Year 3 (e.g., Olympic Games simulation, World Cup held in Montreal), the Competitive State Anxiety Questionnaire (CSAI-2) was used to monitor athletes’ self-regulation skills and also to examine how the athletes were manifesting stress. The CSAI-2 (Martens, Burton, Vealey, Bump, & Smith, 1990) assesses the intensity of cognitive anxiety (characterized by negative expectancies and self-doubt), somatic anxiety (characterized by physiological symptoms such as increased heart rate and muscular tension), and self-confidence. The measure consists of 27 items, divided into three nine-item subscales that assess each of the three components. Subjects respond on a 4-point Likert scale ranging from 1 (not at all) to 4 (very much). Each subscale total ranges from 9 to 36. The CSAI-2 has been shown to be a reliable (Burton, 1998) and valid (Martens, Vealey, & Burton, 1990) measure for assessing competitive state anxiety.
**Test of Attentional and Interpersonal Style (TAIS).** The TAIS (Nideffer, 1976) was used in year 2 to investigate each athlete’s dominant attentional style and to provide coaches with additional information on how best to work with each athlete on an individual basis. Specifically, attentional styles (e.g., Awareness, Analytical/Conceptual, and Action-Focused) were contrasted with distractibility (e.g., external, internal, and reduced flexibility). Confidence was contrasted with self-critical scores, cognitive-behavioral bandwidth (e.g., information processing was contrasted with decision making), behavioral and emotional control (e.g., orientation toward rules and risk, negative and positive expression of criticism and anger), drive and confidence over time (e.g., control, physical competitiveness, need for intellectual expression, performance under pressure, focus over time and confidence/self-criticism) and finally, interpersonal style (e.g., extroversion and introversion). The TAIS contains a total of 144 behaviorally-oriented items describing an individual’s functioning in environmental situations. Participants rated items for the frequency of their occurrence on a 5-point continuum ranging from 1 (never) to 5 (always). The TAIS consists of 17 scales; six measure attentional abilities, two measure behavioral and cognitive controls, and nine describe interpersonal characteristics. The complete TAIS profile provides a description of individual’s attentional and interpersonal strengths and weaknesses. Normative data are available for various populations, and the TAIS has shown good test-retest reliability as well as construct and predictive validity (Nideffer). Attentional style has been shown to discriminate between expert and novice athletes in some studies (Kirschbaum & Bale, 1980; Richards & Landers, 1981), yet other studies have demonstrated equivocal results (Landers, Furst, & Daniels, 1981).

**Biofeedback Stress Report Profiles.** Following completion of the questionnaires, participants entered a sound-attenuated, climate-controlled room and were seated upright in a comfortable chair. Physiological sensors attached to a Flex Comp encoder (Thought Technology) were placed on the arms and chest according to recommendations of Furedy, Shulhan, and Scher (1986) and Gramatikov (1995).

All athletes were given both a psychophysiological stress and electroencephalography (EEG) test (Wilson, 2006) to evaluate individualized responses to stress (year 2, phase three). The stress profile follows a prescribed order (e.g., Stroop task, math task, game task) of 14 tasks for each participant, followed by a 2-min recovery period to examine biofeedback recovery between events.

The sensors were calibrated while athletes adapted to the temperature of the laboratory environment. Next, a pretask baseline level of physiology was established before stress tasks began. Psychophysiological testing and monitoring under varying stress conditions can possibly help the athlete and/or sport psychologist learn what and how the individual manifests their response to stress that may interfere or enhance performance leading to individualized affect-related zones of optimal performance (Cohen, Tenenbaum, & English, 2006; Edmonds, Tenenbaum, Mann, Johnson, & Kamata, 2008; Filho, Moraes, & Tenenbaum, 2008; Hanin, 2000; Johnson, Edmonds, Tenenbaum, & Kamata, 2007). The testing session lasted approximately 45 min. The following is a description of the physiological measures used:

- **Heart rate:** Heart rate (in beats per minute) was obtained using a photoplethysmographic sensor measuring blood volume pulse (BVP) with sensors placed on the left thumb to detect moment-to-moment changes in peripheral blood flow to determine the beat-by-beat heart rate.
• Respiration rate: Respiration rate (RR) was obtained using pneumograph (respiratory strain gauge) sensors placed horizontally in one location across the chest above the belly (approximately 3 cm below the xyphoid process). Excursions of the respiratory muscles corresponding to each breath were recorded (in breaths per minute).

• Heart rate variability: The terms respiratory sinus arrhythmia (RSA) and heart rate variability (HRV) are often used to describe the beat-by-beat value of interbeat interval (IBI), which is derived from the BVP signal or heart rate (number of beats per minute). A major factor influencing HRV is the respiratory cycle; namely, inhalation tends to increase HR and exhalation tends to decrease it. The speeding and slowing of the breathing cycle is called RSA. From a medical perspective, there are many health benefits associated with RSA/HRV training such as reversing illness and enhancing health (Lehrer et al., 2006; Lehrer et al., 2004).

• Muscle activity: Muscle activity was obtained using electromyography (EMG) sensors to record surface electrical activity of muscles corresponding to each contraction (in mV). Two sEMG sensors were placed on the upper left and right medial midpoint of trapezius muscle.

• Skin temperature: Temperature of the skin (in degrees Celsius) was obtained using temperature sensors to record electrical activity of a thermistor corresponding to each tenth of a degree of temperature change. The thermistor was attached to the athlete’s right (dominant) index finger.

• Skin conductance: Skin conductance was a measure of electrical conductivity of the skin corresponding to sweat gland activity (in μS). The skin conductance electrodes were attached to the palmar surface on the index and ring fingers of the athlete’s nondominant hand.

**EEG Stress Report: Neurological Assessment.** Brain activity frequency, measured in hertz (Hz), was obtained using electroencephalography (EEG) sensors attached to a Flex Comp encoder (Thought Technology) for referential monopolar recording of electrical activity (i.e., alpha) of the brain. According to recommendations made by Peper, Tylorva, Gibney, Harvey, and Combatalade (2008), sensors were placed in the following locations: Cz and right and left ear lobes according to the International 10–20 system.

EEG bandwidths, ratios, and interpretation are based upon the work of Thompson and Thompson (2003). The EEG profile includes several frequency bands that have been associated with optimal performance states (Babiloni et al., 2009; Crews & Landers, 1993; Salazar et al., 1990; Wilson, Peper, & Moss, 2006)

**Reaction Time Tests.** These baseline tests were introduced in an educational seminar during the summer camp. The skill acquisition and practice phases were also completed in training as part of the pre-Olympic summer training camp between years 2 and 3 of the program. The reaction-time baseline and training protocol was designed in collaboration with expert equipment engineers of a commercial biofeedback equipment provider. Measurements of reaction time were made using a synchronizing device (e.g., TT-AV Sync, audio/visual device) that allowed accurate measurement to within less than 0.5 ms of synchronized responses during reaction time training (Harvey, Beauchamp, & Beauchamp, 2011).
Intervention Strategies

**Mental Skills Workbook.** A mental skills cognitive-behavioral training workbook (Beauchamp, Halliwell, Fournier, & Koestner, 1996) individualized for the sport of speedskating consisting of 22 modules (e.g., introduction, peak performance, mental toughness, psychological skills and strategies, breaking through your performance barriers, performance profiles, goal setting, concentration and focus, imagery, your ideal performance state, goal setting, confidence, composure, attention control training, imagery, trust, quality practice, precompetition and postcompetition plans, biofeedback and neurofeedback self-regulation training) with exercises following each section to help ensure individualization of the mental skills discussed within each educational seminar (Beauchamp, 2007). The mental skills workbook was used in year 1, phase 5 of the program.

**Educational Seminars.** The National and Development Teams were also subdivided by gender and scheduled at varying times in the weekly training program to facilitate small groups and feedback within the seminars. In phases 5 and 6 of year 1, a schedule was set in conjunction with the YTP and 20 educational seminars were conducted with the men’s and women’s Development Team, whereas the National Team coaches selected the topics most relevant for their teams. Consequently, eight educational sessions were given with the women’s National Team, and six seminars were given with the men’s National Team. The content and schedule of the seminars were decided in advance with the coaches of each team. Follow-up individual consultations were conducted with each athlete to ensure they individualized the material and were utilizing their log book to transfer the material on a daily basis in training. Approximately 90% of the seminars were attended by the respective coaches.

**Mental Training Log Book.** The athletes were asked to consolidate their newly acquired skills from the mental preparation workbook into their training by using a daily log book for the purpose of improving deliberate practice (Janelle & Hillman, 2003). The personal log book was designed to increase both the mindfulness of athletes (e.g., daily goal setting) and to incorporate their cognitive, emotional, and behavioral skills to improve the quality of their daily training. The log book was issued in year 1, phase 6 in conjunction with the mental skills workbook.

**Psychological Warm-Up Precompetition Routine.** Qualitative data in year 1 (i.e., data collected from individual semistructured interviews) suggested that the athletes experienced anxiety and lost their focus during their precompetition warm-up. Consequently, the athletes were taught to integrate their psychological warm-up with the general, dynamic, and specific physical warm-ups in year 1, phase 5. To accomplish this goal, the athletes were taught to self-regulate through the use of microbreaks utilizing cycles of concentration alternating with microbreaks to keep themselves centered and focused on the process.

**Heat Box Preparation.** The heat box is the defined area where athletes are required to present themselves 30 min in advance to a race official before putting on their skates and entering the competition ice following a previous heat/race. Similar to the precompetition warm-up routine, athletes were taught (i.e., year 1, phase 5) to develop an individualized heat box routine utilizing their cycles of concentration where they integrate their psychological skills (e.g., self-talk, imagery, psych-up
strategies, positive emotion selection, process focus goals, mental rehearsal) and alternate their concentration cycle with their quiet mind and/or breathing strategies for self-regulation before their turn to step on the ice.

**Prestart Routine: Year 1, Phase 5.** Prestart routines were structured in the following phases as part of the athlete's mental skills workbook: (a) preparation phase, entering the ice; (b) focus phase, called to the start line by referee signal “go to the start”; and (c) execution phase, responding to the gun or tone to start the race. Athletes were asked to individualize their routines utilizing their psychological skills and strategies toward achieving their IZOF (i.e., individual zone of optimal functioning). Automaticity of their individualized prestart routines integrated with the biofeedback reaction time program was the final step in year 3.

**Biofeedback Training.** The physiological measures included above (e.g., HR, HRV, RR, EMG, SC, ST) were used as real-time feedback to aid athletes in developing self-regulation competencies. Training sessions were conducted on a weekly basis until automaticity was established in each skill area. In year 2, phases 5 and 6, a schedule of four to six sessions per physiological measure (e.g., HRV, six sessions of 45 min) for each athlete was implemented until the athlete developed competency with each element. As HRV training was a core element of the biofeedback training program, on average, six to ten sessions per athlete was conducted in this phase. In addition, HRV was reviewed to cue up the athlete for all subsequent sessions for both biofeedback and neurofeedback training sessions.

**Neurofeedback Training for Relaxation.** The EEG psychological training program (year 2, phase 5) revolved around teaching athletes relaxation training (e.g., alpha training), such that they could relax mentally by reducing negative self-talk (Beta 2–3) while rewarding alpha. Once in this state, athletes were prompted (a) to consider how they got into this state, (b) to provide it with a term to which they could return on demand, (c) to set a goal in training to integrate the skill of quiet mind relaxation and use it with their mental rehearsal in simulated situations, and (d) to employ it in competition.

**Postcompetition 3-Way Race-Plan Debrief.** In discussions with coaches, competition plan decision making was an area targeted for improvement; consequently, 3-way debriefings after competitions were conducted, with the coach, sport psychologist, and athlete watching a video tape to analyze decision making in races (e.g., decisive, hesitant, efficacy of prestart routines, race plan evaluations, percentage passing attempts successful versus failed). Three-way debriefings began in year 2, phase 6. The postcompetition video feedback resulted in follow-up consultations with athletes in terms of vision training and/or decision training as described below.

**Vision Training.** Vision training took place as part of the educational video-debrief analysis and used three types of quiet eye movements: (a) gaze fixations, (b) pursuit tracking, and (c) saccades (Vickers, 2007). Perceptual-motor exercises involving visual eye movement exercises constituted the skill acquisition stage and finally the athletes employed these skills in training as part of the practice stage. These gaze control strategies were used to enhance tactical decision making. An integrated model of decision making includes visual search strategies by either
chunking information or utilizing a visual pivot (Tenenbaum, 2003). Consequently, National Team athletes need to be prompted with respect to where and how they perceive their visual field to interpret the information quickly and make a decisive decision while skating at high speeds under time pressure (Klein, 1999). In addition, the quality of the feedback (e.g., frequency, fading, delayed, reduction) and the direction of the feedback (e.g., coach directed versus athlete initiated control) can potentially have a strong impact on the quality of self-regulation (Janelle, Barba, Frehlich, Tennant, & Caurough, 1997).

Decision Training: Years 2 and 3, Phase 7. Decision training resulted from the postcompetition debrief. The athlete, his or her coach, and the sport psychologist engaged in three-way video feedback to analyze decision-making skills relative to each athlete’s competition plan set before each race in competition. Decision making was evaluated by classifying specific events as hesitation, no decision, aggressive decision, and/or decisive decisions. The decision training component utilizes Vickers’ three-step decision training model from the seven decision tools described in the program (Vickers, 2007): (a) bandwidth feedback, (b) questioning, and (3) video feedback. These feedback sessions were conducted both as part of the simulation training and postcompetition debrief.

Reaction Time Biofeedback Training: Year 3, Phase 6. Reaction time (RT) biofeedback was used off-ice to more effectively prepare 500-m sprinters with respect to their prestart routines. Reaction time baselines were done toward the end of year 2 and the RT training program was embedded into the YTP for year 3 to correspond to the on-ice speed microcycles of the men’s and women’s YTP. The equipment was engineered in an effort to improve neural synchrony between the auditory reaction time and the perceptual motor system of hearing a gun or tone at the start with the initiation of the first foot movement forward (Harvey et al., 2011). Empirical research has provided some support for the relationship between anticipatory reaction time speeds, decision time, automaticity, choice reaction time, attentional states, and expertise (Abernathy, Maxwell, Masters, van der Kamp, & Jackson, 2007; Schneider & Shiffrin, 1977).

In addition, athletes were trained in a room with crowd noise and a picture of the Olympic venue on the ice that was created on a second monitor to replicate the on-ice multisensory environment as close as possible. The biofeedback measurements included ST, EMG, HR, RR, HRV, SC, and EEG described above. Consequently, athletes received instant feedback on their individual zone of optimal functioning (Hanin, 2000). Moreover, from the education seminars, athletes were encouraged to use (a) their individualized optimal emotion on a continuum from low positive to high positive (Loehr & Schwartz, 2003) with their optimal arousal/activation levels on a scale of 0–10 (Zaichkowsky & Takenaka, 1993), (b) their start focus (e.g., eyes fixed on first block; Vickers, 2007), (c) confident self-talk (Orlick, 1986), (d) ideal level of muscle tension and arousal for best RT start (Zaichkowsky & Takenaka, 1993), (e) diaphragmatic breathing on a 5–6 count before getting into position and focused slow exhalation once in the start position to encourage heart rate deceleration (Strack, 2003), and (f) a quiet mind (i.e., peak alpha frequency) 3 s before the variable tone and/or the start gun (Deeny, Hillman, Janelle, & Hatfield, 2003).

Simulated Competition Events: Year 3, Phase 6. Simulated competition events in training and pre-Olympic simulations were conducted to prepare athletes for competition and to fine tune their precompetition functioning, competition plans,
and prestart routines. For example, simulated race events also demanded that athletes make decisive tactical decisions within race conditions against their fellow competitors. Three simulated events appeared to serve this purpose. First, a World Cup held in Canada four months before the Olympic Games served as our test event. Second, a full pre-Olympic simulation event was held 6 weeks prior the Games in which International skaters along with Canadian skaters who were not selected for the Olympic Games were invited to participate. Finally, the team held a pre-Olympic camp 1 hr away from the Olympic Games venue the week before arriving at the Games. Final staging with all of the Olympic clothing and final team preparation were completed at this time.

Monitoring Strategies

**Individual Performance Profiles (IPP).** Individual profiles were completed for each athlete. These included a power point presentation of each athlete’s quantitative tests and coaches’ qualitative comments as part of the yearly evaluation process. In addition, each profile contained performance statistics graphed for each competition by event category for the competition year. The IPP in year 1 included the coaches’ qualitative comments and the data from OMSAT, RESTQ-S, and performance statistics. In year 2, the IPP included coaches’ qualitative comments, gap analysis, action plan, OMSAT, RESTQ-S, TAIS, biofeedback physiology stress report, neurofeedback EEG stress report, race plan decision analysis from video profile, and World Cup performance statistics. In year 3, the IPP included the same reports as in year 2, with the addition of (a) key performance indicators; (b) reaction time starts data report; (c) CSAI-2 report; (d) daily and weekly log book data, monthly RESTQ-S profiles, and regeneration qualitative report; and (e) individual highlight videos. The performance profiles were part of year 1, phase seven evaluation process, which was also used for the gap-analysis and action plans the following year in phase one of years 2 and 3.

**Key Performance Indicators (KPI).** From the data collected and the experiential knowledge gathered and shared with the coaches, three key performance indicators could be identified for each athlete 6 weeks before the Olympic Games. For example, utilizing a three-column page, three critical KPIs for each athlete were identified with respective coaches (e.g., emotion management, rest and recovery, confidence, focus, poor training, family, media issue). The second column highlighted the feedback mechanism being used (e.g., emotional preparation: What if plan—poor early Olympic Games performance resulting in frustration, negative affect, and negative cognitions). The third column outlined the optimal intervention and person responsible for dealing with the critical KPI. For example, possible emotional recovery strategies might consist of discussion with the coach, a walk outside Olympic Village to enhance perspective, and utilization of highlight tapes to get back on track.

**Conclusion**

The goal of the integrated PST program presented herein was to prepare each individual athlete for her or his best performance under the pressure of the Olympic Games. The team achieved its goals both from a team perspective and an individual perspective. First, the short-track speed skating team won two gold medals, two silver medals, and one bronze medal. Second, from an individual perspective, 14
athletes were finalists in their events. In addition, the International Skating Union’s overall individual and team rankings also improved during the period of 2007–2010.

The integration of mental skills (e.g., relaxation, imagery, self-talk, focus, breathing, reaction time readiness, music relaxation) and biofeedback self-regulation with athletes’ preperformance routines (e.g., week before, night before, competition day routines and competition plans, postcompetition debriefs), integrated activation and relaxation cycles in warm-up before competitions (e.g., general, dynamic and competition specific), and the individualized precompetition routines and rest and recovery plans, may possibly have each contributed to the success of the skaters in World Cup competitions and the 2010 Vancouver Olympic Games. However, further empirical study is needed to test causality and to identify the relative contribution of each of the components of the integrated PST program to performance. Studies are also needed from multiple sports in various settings utilizing a variety of methodologies.

The principal advantage of utilizing an integrated psychological and biofeedback 3-year training program such as the one described herein is that it is a systematic approach to the design, scope, and sequencing of decisions regarding interventions. Mental and self-regulation skills can then be monitored individually for their effectiveness, allowing for constructive feedback for the athlete, coach, and sport psychologist.

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References


