

Studies Using Single-Subject Designs in Sport Psychology: 30 Years of Research

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A prominent feature of behavior-analytic research has been the use of single-subject designs. We examined sport psychology journals and behavioral journals published during the past 30 years, and located 40 studies using single-subject designs to assess interventions for enhancing the performance of athletes and coaches. In this paper, we summarize that body of research, discuss its strengths and limitations, and identify areas for future research.

Key words: single-subject research, sport psychology, behavioral athletics, behavioral sport psychology

In the 1974 issue of the *Journal of Applied Behavior Analysis (JABA)*, T. L. McKenzie and Rushall published the first research in applied behavior analysis in a sport setting. That study was consistent with many of the dimensions of applied behavior analysis described by Baer, Wolf, and Risley (1968), not the least of which was a recommendation for the use of single-subject designs for demonstrating experimental control over the target behavior. During the past 30 years, research in sports that used single-subject designs has steadily increased. Based on our inclusion criteria (described later), such research has averaged 0.6, 1.2, and 2.2 published articles per year during each of the past three decades, respectively. The purposes of this paper are to summarize that body of research, discuss its strengths and limitations, and identify areas for future research. But first we will describe some milestones of behavioral sport psychology.

SOME HISTORICAL HIGHLIGHTS OF BEHAVIORAL SPORT PSYCHOLOGY

Behavioral applications in sports were first described by Rushall and

Siedentop in *The Development and Control of Behavior in Sport and Physical Education* (1972). Drawing heavily from the writings of Skinner, they described numerous practical strategies for shaping new sport skills, maintaining existing skills at high levels, and generalizing practice skills to competitive settings. In 1974, T. L. McKenzie and Rushall published the first study to use a single-subject design in a sport setting. Also in the 1970s, Smith, Smoll, and their colleagues at the University of Washington conducted a series of studies on the assessment and modification of behaviors of Little League baseball coaches (for a review of behavioral assessment and interventions in youth sports, see Smith, Smoll, & Christensen, 1996). Another important contribution from that era was a book by Dickinson (1977) that offered an insightful Skinnerian analysis of the contingencies that both promote and deter participation in sports. Other publications in behavioral sport psychology in the 1970s and the early 1980s included an analysis of feedback provided by youth baseball coaches (T. L. McKenzie & King, 1982), application guidelines for coaches (e.g., Smoll, Smith, & Curtis, 1978), case histories with before-and-after data (e.g., Martin, LePage, & Koop, 1983), additional research using single-subject designs (e.g., Allison & Ayllon, 1980; Koop & Martin, 1983), and a book of readings

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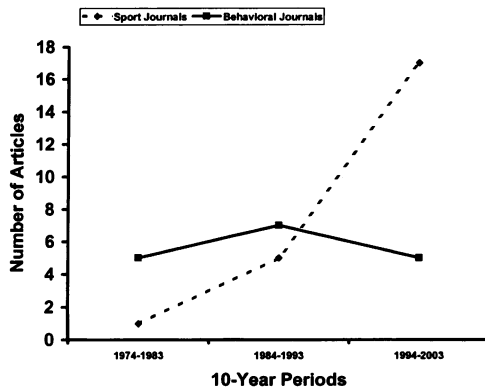


Figure 1. The number of studies using single-subject designs in sport psychology during the past 30 years that met the inclusion criteria.

(Martin & Hrycaiko, 1983a). Thus, a behavioral approach to sport psychology had a promising start.

In the 1980s and early 1990s, more traditional approaches in sport psychology experienced considerable growth in North America, as evidenced by the establishment of several journals (e.g., *Journal of Sport Behavior* in 1979; *Journal of Sport Psychology*, now called *Journal of Sport and Exercise Psychology*, in 1979; *The Sport Psychologist* in 1986; and *Journal of Applied Sport Psychology* in 1989), the publication of numerous books, frequent national and international conferences, and the establishment of the Association for the Advancement of Applied Sport Psychology (AAASP) in 1986. In the meantime, during that same period, behavioral research in sports using single-subject designs averaged only one article per year. During the last decade, however, research in sport psychology using single-subject designs doubled the rate of the previous two decades. One determinant of this growth is likely the repeated calls in sport psychology journals for increased use of single-subject designs (Bryan, 1987; Hrycaiko & Martin, 1996; Wollman, 1986). As indicated in Figure 1, this recent growth is evident in sport journals but not for research on sports in behavioral journals. Other possible determinants of this recent

growth include a very positive review (Smith & Little, 1998) of a book (Martin, 1997) and an assessment manual (Martin, Toogood, & Tkachuk, 1997) on a behavior-analytic approach to sport psychology, and the offering of behavioral sport psychology courses at several universities including Auburn University, California State University at Long Beach, University of Manitoba, University of Nebraska, University of Nevada at Reno, University of Redlands, San Diego State University, SUNY College at Cortland, and Siena College. We turn now to a description of the inclusion criteria used for our review.

INCLUSION CRITERIA

We used four inclusion criteria. First, the research participants had to be athletes who competed on a regular and organized basis. Studies of participants selected for convenience, such as college students (e.g., A. D. McKenzie & Howe, 1997) or members of a physical activity class (e.g., Ram & McCullagh, 2003) were not included. This was in keeping with the applied dimension of applied behavior analysis described by Baer et al. (1968), in which there is typically a close relation between the behavior and stimuli under study and the subjects with whom they are studied.

Second, the dependent variable had to be a direct measure of athletic performance during actual practices or competitions that were considered to be typical for athletes in the sport that was studied. Contrived situations selected for convenience, such as a dart-throwing task (A. D. McKenzie & Howe, 1997), were not included. Also, studies in which the dependent variable was measured via questionnaires, such as the study by Callow, Hardy, and Hall (2001) on the confidence of badminton players, were not included. In keeping with the behavioral dimension described by Baer et al. (1968), we were interested in research that experimentally examined the impact of in-

terventions on what competitive athletes could do, not on what they had to say about their performance.

Third, studies were included only if they reported acceptable interobserver reliability data on the dependent measures, or gave "game statistics" data on objective measures, such as free throws made in basketball. This criterion is consistent with the behavioral dimension described by Baer et al. (1968). This led to exclusion of three studies using single-subject designs, two (D. Scott, Scott, & Howe, 1998; Shambrook & Bull, 1996) that did not report reliability data and one (Annesi, 1998) that reported average subjective ratings of tennis performance between coach and player without formal measurement of reliability.

Fourth, studies were included only if they presented graphs of the performance of individual subjects across baseline and treatment sessions (vs. before-and-after assessments) and used a single-subject research design. Thus, although Hanton and Jones (1999) provided continuous measures of anxiety ratings obtained from questionnaires across a number of swimming meets, swimming performance was reported only in terms of the percentage improvement in race times from the start to the completion of the study. Therefore, that study was not included. Buzas and Ayllon (1981) compared standard coaching to differential reinforcement for improving tennis skills of 3 female youth tennis players; however, they provided only mean scores during baseline and intervention conditions. Therefore, that study was not included. Two studies were included even though they presented graphs of the average performance of groups (not the performance of individuals) across sessions. Komaki and Barnett (1977) investigated a behavioral package for improving the play execution of the offensive backfield on a youth football team in a multiple baseline design across plays. Ziegler (1987) investigated a four-step verbal cuing technique for improving ground strokes of begin-

ning tennis players in a multiple baseline design across three groups. These studies were included because they were consistent with most dimensions of applied behavior analysis described by Baer et al. (1968), provided a believable demonstration of experimental control over the behavior of groups, and indicated that all players improved (Komaki & Barnett) or provided averaged data for individual subjects that indicated improvement (Ziegler). Case histories and AB designs (e.g., Jones, 1993; Silva, 1982) were not included.

Beginning with 1968, all issues in three behavioral journals and four sport journals were examined for articles that met the above criteria. The behavioral journals were *Behavior Modification*, *Behavior Therapy*, and *JABA*. The sport journals were *Journal of Applied Sport Psychology*, *Journal of Sport Behavior*, *Journal of Sport and Exercise Psychology*, and *The Sport Psychologist*. In addition, articles from other journals cited in papers that met the inclusion criteria were also included, provided that such articles also met the inclusion criteria. No restrictions were placed on studies based on the nature of the interventions.

SUMMARY OF THE RESEARCH

Forty studies met the inclusion criteria. They are summarized by sport in Table 1.

Subject Characteristics

A total of 222 individuals participated in the 40 studies, including 119 males and 103 females. Of the participants, 101 were college athletes, 87 were youth athletes, 31 were recreational athletes, 2 were international competitors, and 1 was a coach.

Increasingly, practitioners are applying interventions to attempt to improve the performance of athletes in international competitions. At the 1996 Olympic games in Atlanta, for example, over 20 practitioners provided sport psychology services for the American team alone ("Role of Psychology,"

TABLE 1

Research in sports using single-subject designs that met the inclusion criteria

Sport	Study	Partici- pants	Target behaviors	Design	Intervention	Proce- dural re- liability or treat- ment integrity
Ballet	Fitterling and Ayllon (1983)	4 female youth	4 ballet skills; P	Combined MB across subjects, ABAB	Instructions, freeze technique, modeling, and feedback	No
Baseball	Osborne, Rudrud, and Zezoney (1990)	5 male college players	Number of "well-hit" curve balls; P	Alternating treatments	Marked vs. unmarked seams	No
Basketball	Hamilton and Fremouw (1985)	3 male college players	Free-throw percentage; C	MB across subjects	Relaxation, self-talk, mental rehearsal	Yes
	Kendall, Hrycaiko, Martin, and Kendall (1990)	4 female college players	Correct execution of a defensive skill; C	MB across subjects	Relaxation, self-talk, mental rehearsal	Yes
	Kearns and Crossman (1992)	3 male college players	Free-throw percentage; P, C	MB across subjects	Relaxation and imagery	Yes
	Templin and Vernacchia (1995)	5 male college players	Field-goal percentages; C	MB across subjects	Viewing highlight music videos	Yes
	Lerner, Ostrow, Yura, and Etzel (1996)	12 female college players	Free-throw percentages; P	MB across subjects and ABA	Goal setting vs. goal setting and imagery vs. imagery	Yes
	Kladopoulos and McComas (2001)	3 female college players	Free-throw percentage, proper shooting form; P	MB across subjects	Instruction for proper form and praise for correct form	No
	Pates, Maynard, and Westbury (2001)	3 male college players	Rating of free-throws and jump shots; P	ABA	Hypnosis plus a "trigger" word	Yes
	Pates, Cummings, and Maynard (2002)	5 male college players	Rating of three-point shots; P	MB across subjects	Hypnosis plus a "trigger" word	Yes
	Swain and Jones (1995)	4 male college players	Offensive rebounds, defensive rebounds, steals, turnovers; C	Modified multiple design	Goal setting and feedback	Yes

TABLE 1

Continued

Sport	Study	Partici- pants	Target behaviors	Design	Intervention	Proce- dural re- liability or treat- ment integrity
Figure skat- ing	Hume, Martin, Gonzalez, Cracklin, and Gen- thon (1985)	3 female youth skaters	Number of jumps and spins at- tempted; P	ABAB	Instructions, public self- monitoring, and coach feedback	Yes
	Ming and Martin (1996)	3 female and 1 male youth skaters	Correctness of traced fig- ures; P	Multielement	Self-talk pack- age	Yes
Football	Komaki and Barnett (1977)	5 male youth football players	Play execution of the offen- sive back- field; P, C	MB across plays	Instructions, modeling, a performance checklist, and feed- back	No
	Allison and Ayllon (1980) ^a	5 male youth players	Offensive blocking; P	MB across 4 subjects, and ABAB (1 subject)	Instructions, freeze tech- nique, mod- eling, and feedback	No
	Ward and Carnes (2002)	5 male college line- backers	Correct reads, drops, and tackles; P, C	MB across be- haviors	Goal setting and public posting	No
	Ward, Smith, and Sharp (1997)	5 male college wide re- ceiv- ers	Blocking, run- ning routes; P, C	ABAB	Goal setting and public posting	No
Golf	Pates, Oliver, and May- nard (2001)	5 male adult "casu- al" golfers	Distance from the hole in putting; P	MB across subjects	Hypnosis and a "trigger" behavior	Yes
Gymnastics	Allison and Ayllon (1980) ^a	6 female youth gym- nasts	Reverse kips, front hand springs, backward walkovers; P	MB across skills and behaviors with rever- sals	Instructions, freeze tech- nique, mod- eling, and feedback	No
	Wolko, Hry- caiko, and Martin (1993)	5 female youth gym- nasts	Number of balance beams skills attempted and com- pleted; P	Alternating treatments	Public vs. pri- vate goal setting and self-record- ing, and feedback	Yes
Ice hockey	Rogerson and Hrycaiko (2002)	4 male youth goal- tenders	Save percent- age; C	MB across subjects	Relaxation and self-talk	Yes

TABLE 1

Continued

Sport	Study	Partici- pants	Target behaviors	Design	Intervention	Proce- dural re- liability or treat- ment integrity
Pole vault	D. Scott and Scott (1997)	1 male adult interna- tional competi- tor	Arm extension at take-off; P	Changing-cri- terion de- sign	Prompting and shaping with elec- tronic feed- back	No
Rowing	L. M. Scott, Scott, Bed- ic, and Dowd (1999)	5 female and 4 male adult novice rowers	Distance rowed in- doors during a 40-min er- gometer workout; P	MB across subjects	An audio asso- ciation tape, a music dis- association tape, or a disassocia- tion video- tape of row- ing races	Yes
Soccer	Rush and Ayl- lon (1984)	9 male youth players	Heading, throw-ins, and goal kicks; P	Combined MB across sub- jects and ABAB; changing criterion	Instructions, freeze tech- nique, mod- eling, and feedback; shaping	No
	Ziegler (1994)	4 male college players	Four soccer drills; P	MB across subjects	Information, attention drills	No
	Brobst and Ward (2002)	3 female youth players	Movement with ball, movement during re- starts, and movement after pass- ing; P, C	MB across be- haviors	Goal setting, public post- ing, and oral feed- back	Yes
Speed skat- ing	Wanlin, Hry- caiko, Mar- tin, and Ma- hon (1997)	4 female youth skaters	Number of laps and drills com- pleted; 500 meter race times; P, C	MB across subjects	Goal-setting, self-moni- toring, self- talk, imag- ery package	Yes
Swimming	T. L. Mc- Kenzie and Rushall (1974)	4 male and 4 female youth	Number of laps com- pleted; P	ABAB	Instructions and public self-record- ing	Yes
	Rushall and Smith (1979)	1 male adult swim- ming coach	Rates of rein- forcement, feedback, and rein- forcement plus feed- back given to swim- mers; P	MB across be- haviors	Self-recording and fading	Yes

TABLE 1

Continued

Sport	Study	Partici- pants	Target behaviors	Design	Intervention	Proce- dural re- liability or treat- ment integrity
Tennis	Koop and Martin (1983)	3 female and 2 male youth	Freestyle, backstroke technique; P	MB across subjects and skills	Instruction, prompting, modeling, and rein- forcement	Yes
	Hazen, John- stone, Mar- tin, and Sri- kameswaran (1990)	1 male and 6 female youth	Freestyle flip turn, back- stroke spin turn, free- style swim component; P	MB across subjects	Videotaping feedback package	Yes
	Critchfield and Vargas (1991)	4 female and 3 male youth	Number of pool lengths swum in 10 minutes; P	Modified MB across sub- jects	Instructions vs. self-record- ing vs. pub- lic self- graphing	Yes
	Hume and Crossman (1992)	3 male and 2 female youth	Productive and unproduc- tive behav- iors; P	ABAB	Goal setting and music reinforce- ment	No
	Allison and Ayllon (1980) ^a	1 male and 4 female adult novices	Forehand, backhand, serve; P	MB across skills and subjects	Instructions, freeze tech- nique, mod- eling, and feedback	No
	Ziegler (1987)	14 female and 10 male college begin- ning players	Forehand and backhand returns; P	MB across groups	A four-step self-talk cueing strat- egy	No
Track and triathlon	Galvan and Ward (1998)	4 male and 1 female college players	Inappropriate on-court be- haviors; C	MB across subjects	Instructions and public posting	No
	Landin and Hebert (1999)	5 female college players	Volleying skill; P, C	MB across subjects	A two-word self-talk strategy	Yes
	Shapiro and Shapiro (1985)	1 male and 2 female youth	Conditioning, form, starts; P	MB across be- haviors	Instructions, freeze tech- nique, mod- eling, and feedback	No
	Patrick and Hyrcaiko (1998)	1 male adult elite runner and 3 male adult triath- letes	Time to com- plete 1,600- m runs; P	MB across subjects	Goal setting, relaxation, imagery, and self-talk package	Yes

TABLE 1

Continued

Sport	Study	Participants	Target behaviors	Design	Intervention	Procedural reliability or treatment integrity
	Thelwell and Greenlees (2001)	5 male adult recreational athletes	Gymnasium triathlon performance (rowing, cycling, running); P	MB across subjects	Goal setting, relaxation, imagery, and self-talk package	Yes
	Thelwell and Greenlees (2003)	4 male adult recreational athletes	Gymnasium triathlon performance (rowing, cycling, running); P	MB across subjects	Goal setting, relaxation, imagery, and self-talk package	Yes
Volleyball	T. L. McKenzie and Liskevych (1983)	6 female college players	Service reception; P	Alternating treatments design	Monetary reinforcer vs. private coach instruction	No

Note. MB = multiple baseline; P = dependent variable measured at practices; C = dependent variable measured during competitions.

* Allison and Ayllon (1980) is listed three times because they studied three different sports.

1996). Thus, it was surprising that only 2 of the participants were international competitors. Also, considering the increased reference in the media to use of sport psychology consultants by professional athletes, it is surprising that no studies reported professional athletes as participants.

Types of Sports

Nine studies focused on basketball; six focused on swimming; four focused on each of football, tennis, and track or triathlon; three focused on soccer; two each focused on figure skating and gymnastics; and one each focused on ballet, baseball, golf, ice hockey, pole vaulting, rowing, speed skating, and volleyball.

Intervention Characteristics

Goal setting. Goal setting was a prominent feature of the interventions in 11 studies. These can be divided

into three categories: goal setting and public posting, goal setting and feedback or reinforcement, and goal setting as a part of "mental training" packages.

Three studies demonstrated goal setting and public posting to be an effective intervention. Ward and Carnes (2002) used it to increase correct reads, drops, and tackles made by college linebackers in football. Ward, Smith, and Sharp (1997) used it to increase blocking and running routes of college wide receivers in football. Brobst and Ward (2002) used it to increase skills of youth soccer players.

Three studies involved goal setting and feedback or reinforcement. Swain and Jones (1995) used goal setting and feedback to increase offensive rebounds, defensive rebounds, steals, and turnovers of college players during basketball games. Hume and Crossman (1992) used goal setting and music reinforcement to increase productive be-

haviors (i.e., doing sit-ups before practice, swimming sets assigned by the coach, etc.) and decrease nonproductive behaviors (i.e., eating, taking someone's goggles, etc.) of youth swimmers at practices. Lerner, Ostrow, Yura, and Etzel (1996) studied goal setting and feedback to increase free-throw performance of college basketball players at practices. The intervention produced small positive effects for 3 of 4 participants. Goal setting combined with imagery produced small positive effects for 1 of 4 additional participants.

Five studies used goal setting as a part of a multiple-component "mental training" package. The interventions were effective in improving various practice behaviors of young gymnasts (Wolko, Hrycaiko, & Martin, 1993), speed skaters (Wanlin, Hrycaiko, Martin, & Mahon, 1997), 1,600-m runners (Patrick & Hrycaiko, 1998), and gymnasium triathletes (Thelwell & Greenlees, 2001, 2003).

Self-talk and imagery. Self-talk and imagery were both components of multiple-component "mental training" packages in seven studies. These packages were effective in improving free-throw performance during basketball games of college players (Hamilton & Fremouw, 1985), correct execution of a defensive skill by college basketball players during games (Kendall, Hrycaiko, Martin, & Kendall, 1990), performance of compulsory figures by figure skaters at practices (Ming & Martin, 1996), number of laps and drills completed at practices by youth speed skaters (Wanlin et al., 1997), time to complete 1,600-m training runs of adult runners (Patrick & Hrycaiko, 1998), and gymnasium triathlon performance of adult recreational athletes (Thelwell & Greenlees, 2001, 2003).

Kearns and Crossman (1992) and Lerner et al. (1996) studied imagery training for improving free-throw performance of college basketball players. Imagery plus relaxation produced very small increases in performance for 3 of 3 players (Kearns & Crossman). Im-

agery training alone did not improve performance for 4 players (Lerner et al.). Imagery training combined with goal setting produced small positive effects for 1 of 4 additional players (Lerner et al.).

Landin and Hebert (1999) used a two-word self-talk strategy for improving volleying skills of college tennis players at practices. Ziegler (1987) used a four-step self-talk procedure for cuing forehand and backhand returns of beginning tennis players. Rogerson and Hrycaiko (2002) studied relaxation and self-talk for improving save percentages of goaltenders in ice hockey games, and reported very small effects.

Self-monitoring. Five studies featured self-monitoring as a part of the interventions. Three of the studies included a public self-monitoring component as a part of the intervention, and these led to improved performance at practices of youth figure skaters (Hume, Martin, Gonzalez, Cracklen, & Genthon, 1985), youth swimmers (T. L. McKenzie & Rushall, 1974), and youth gymnasts (Wolko et al., 1993). Two of the studies included private self-monitoring (along with other contingencies) in one of the phases, and this was effective in improving skills performed by young female gymnasts at practices (Wolko et al., 1993) and the behavior-management skills of an adult swimming coach (Rushall & Smith, 1979). Critchfield and Vargas (1991) compared self-recording to self-recording plus public self-graphing for improving the number of pool lengths swum by young swimmers, and public self-graphing did not lead to further improvements beyond that which occurred during self-recording.

Instructions, freeze technique, modeling, and feedback. Four studies investigated a behavioral package that included the "freeze" technique for improving skills of youth athletes at practices. With this package, a coach first provides instructions for correct performance of a skill, and the athlete then attempts to perform that skill. If a coach notices that some part of the

skill is incorrect, the coach yells, "freeze!" While the athlete remains in a frozen position, the coach models and explains the correct position. The athlete then continues to perform the skill and is praised if it is performed correctly. This strategy has proven effective for improving skills of youth ballet dancers (Fitterling & Ayllon, 1983), offensive blocking of youth football players (Allison & Ayllon, 1980), gymnastics skills of youth gymnasts (Allison & Ayllon), soccer skills of youth soccer players (Rush & Ayllon, 1984), forehand and backhand serves of youth tennis players (Allison & Ayllon), and conditioning, form, and starts of youth sprinters (Shapiro & Shapiro, 1985).

Hypnosis. Three studies examined hypnosis combined with a behavioral "trigger." The intervention was effective for improving, at practices, free throws and jump shots of college basketball players (Pates, Maynard, & Westbury, 2001), three-point shots of college basketball players (Pates, Cummings, & Maynard, 2002), and putting accuracy of recreational golfers (Pates, Oliver, & Maynard, 2001).

Varied interventions. Seven of the remaining eight studies examined various interventions at practices including instructions and prescriptive praise for improving form of foul shooting of college basketball players (Kladopoulos & McComas, 2001), private coach lessons versus money as consequences for improving service-reception accuracy of college volleyball players (T. L. McKenzie & Liskevych, 1983), marked versus unmarked seams to improve hitting in college baseball players (Osborne, Rudrud, & Zezoney, 1990), prompting and shaping with electronic feedback to improve the form of an international-level pole vaulter (D. Scott & Scott, 1997), a comparison of several music tapes to improve rowing performance of adult novice rowers (L. M. Scott, Scott, Bedic, & Dowd, 1999), information and attention drills to improve soccer skills of college players (Ziegler, 1994), and

a videotaping feedback package for improving performance of youth swimmers (Hazen, Johnstone, Martin, & Srikameswaran, 1990). Templin and Vernacchia (1995) evaluated the viewing of highlight music videos for improving field-goal percentages of basketball players during games, which was not effective. A highlight music video shows instances of a player performing well in a recent game, with background music selected by that player.

Dependent-Variable Characteristics

Work harder at practices. Eight studies examined contingencies that were concerned with influencing athletes to work harder at practices. These included strategies to influence figure skaters to do more jumps and spins (Hume et al., 1985), gymnasts to attempt and complete more balance beam skills (Wolko et al., 1993), rowers to row farther during a 90-min workout (L. M. Scott et al., 1999), swimmers to swim more laps in a set time (Critchfield & Vargas, 1991; T. L. McKenzie & Rushall, 1974), and runners to have faster training runs (Patrick & Hrycaiko, 1998) or faster gymnasium triathlon performance (Thelwell & Greenlees, 2001, 2003).

Decreasing problem behaviors. Two studies focused on decreasing problem behaviors. Galvan and Ward (1998) successfully decreased inappropriate on-court behaviors during matches involving college tennis players, and Hume and Crossman (1992) decreased nonproductive behaviors and increased productive behaviors of youth competitive swimmers at practices.

Coaching behaviors. Rushall and Smith (1979) successfully increased the rates of reinforcement, feedback, and reinforcement plus feedback given to youth competitive swimmers by an adult swimming coach at practices.

Skill improvement. The remaining 29 studies focused on improving athletic skills of athletes in a variety of sports (see Table 1). All of the studies

but one focused on individual skills in individual sports (e.g., freestyle stroke in swimming), or individual skills within team sports (e.g., free-throw performance in basketball). One study (Komaki & Barnett, 1977) focused on team behaviors (behaviors that involve 2 or more players for correct execution).

Procedural Reliability or Treatment Integrity

A procedural reliability assessment insures that an intervention was applied as intended. In a formal procedural reliability assessment, two observers independently evaluate whether or not specific components of an intervention were applied as described by the experimenter. A procedural reliability score can then be computed to provide a measure of procedural reliability. A treatment-integrity check is also a strategy to insure that an intervention was applied and experienced as intended; however, a treatment-integrity check typically does not include a formal reliability assessment of the application of the specific components of an intervention. For example, in the Hamilton and Fremouw (1985) study, basketball players were helped to increase positive statements and self-instructions, and to decrease negative and interfering statements, at the time of conducting free throws during games. As a treatment-integrity check, subjects reconstructed their thoughts while they watched videotapes of themselves shooting free throws during games, and raters rated the extent to which coded thoughts included positive statements, negative statements, and interfering statements. As another example, Kendall et al. (1990) used a relaxation, self-talk, and mental rehearsal strategy before games to improve the correct execution of a defensive skill of college basketball players during games. As a treatment-integrity check, athletes were requested to keep logs of their self-talk and imagery ses-

sions and to return them to the experimenter.

As can be seen in Table 1, 25 of the studies included either a procedural reliability assessment or a treatment-integrity check. The remaining 15 studies did not do so.

Demonstrations of Experimental Control

One of the dimensions of an applied behavior analysis identified by Baer et al. (1968) is the analytical dimension, which calls for a demonstration of experimental control. The most common method for assessing evidence of experimental control in single-subject designs has been visual inspection of graphs of individual data across baseline and treatment sessions. In analyzing the studies contained in Table 1, the authors agreed that there was a demonstration that the interventions were responsible for corresponding changes in the dependent variables in all but four studies (Kearns & Crossman, 1992; Lerner et al., 1996; Rogerson & Hrycaiko, 2002; Templin & Vernacchia, 1995). To obtain an independent judgment of treatment effects in those four studies, eight 4th-year honors students in a course on applied behavior analysis at the University of Manitoba were shown the graphs from each of the studies and were asked,

Considering the criteria described by Martin and Pear (2003) for judging whether a treatment had an effect on a dependent variable, namely, the number of successful replications of a treatment within and across participants, overlapping data points between adjacent phases, the size of the effect, and the immediacy of the effect, please indicate whether or not you believe that there was a treatment effect for each participant.

The students had previously studied Baer et al. and had analyzed a number of studies from *JABA* in terms of the seven dimensions of an applied behavior analysis. Seven of the eight students judged that there was no demonstration of a treatment effect for any of the participants in the Rogerson and Hrycaiko study or in the Templin and Vernacchia study. Four of the eight stu-

dents thought that there was a demonstration of experimental control for Subject B in Kearns and Crossman, whereas five of the eight students thought that there was no demonstration of control for Subjects A and C. Lerner et al. studied free-throw performance of basketball players under conditions of goal setting (4 subjects), imagery (4 subjects), and imagery plus goal setting (4 subjects). Five of the eight students judged that there was a demonstration of a treatment effect for 3 of 4 participants who received goal setting and for 1 of 4 participants who received goal setting plus imagery, but there was no effect for the 4 participants who received imagery alone.

Assessment of Generality of Behavior Change

Baer et al. (1968) suggested that generality occurs when the target behavior transfers from the training situation to new environments (i.e., stimulus generalization), when training leads to the development of new behavior that has not been specifically trained, or when the trained behavior is maintained over time following the withdrawal of training contingencies. Regarding stimulus generalization, six studies intervened at practices, measured performance at practices, and also assessed performance during games or competitions. There was clear evidence of generalization of treatment effects to games in all six studies, including improved performance in games or competitions for 15 football players (Komaki & Barnett, 1977; Ward & Carnes, 2002; Ward et al., 1997), 3 speed skaters (clear effects for 1, small effects for 2; Wanlin et al., 1997), 3 tennis players (clear effects for 2, small effects for 1; Landin & Herbert, 1999), and 3 soccer players (clear effects on two of three skills for 1 player and one of three skills for each of 2 players; Brobst & Ward, 2002).

Several studies examined a behavioral instruction package that consisted of instructions, the freeze technique,

modeling, and feedback to teach sport skills. Two of those studies examined the occurrence of the skills to probes of "standard coaching" and reported generalization of ballet skills in 4 of 4 subjects (Fitterling & Ayllon, 1983) and of tennis skills for 3 of 3 subjects (Allison & Ayllon, 1980). A third study reported stimulus generalization of soccer skills following the behavioral coaching package with 3 of 3 participants, and this generalization did not occur when the skills were taught with standard coaching (Rush & Ayllon, 1984).

Koop and Martin (1983) examined a multiple-component intervention for reducing swimming stroke errors of age-group swimmers. The intervention was applied in a training pool, and results generalized to the regular practice pool. One additional study (Hazen et al., 1990) examined a videotaping feedback package for improving freestyle strokes of youth competitive swimmers. Improvements demonstrated in a training pool generalized to time trials in a different pool.

Regarding the spread of intervention effects to nontargeted performance areas, 11 studies used a multiple baseline across behaviors design (see Table 1). In only one of these studies (Koop & Martin, 1983) was there some evidence of the effects of the intervention on a nontargeted behavior. Koop and Martin examined a multiple-component intervention for reducing swimming stroke errors with age-group swimmers. For 2 participants, the intervention was introduced first to errors in freestyle and then to errors in backstroke. When the intervention was introduced to freestyle, there was no evidence of improvement in the backstroke. However, within each style of swimming, applying the intervention to decrease an error on one component led to substantial overall error decreases in untrained components.

Only four of the 40 studies included a formal follow-up phase to assess maintenance of improvements over time. All four studies (Brobst & Ward,

2002; Hazen et al., 1990; Koop & Martin, 1983; Rushall & Smith, 1979) reported successful follow-up performance.

Practice Versus Competitive Performance

Five studies examined interventions to improve performance at games or competitions and measured performance only during games. Three of these studies focused on college basketball players and successfully improved free-throw percentages (Hamilton & Fremouw, 1985); correct execution of a defensive skill (Kendall et al., 1990); and offensive rebounds, defensive rebounds, steals, and turnovers (Swain & Jones, 1995). The fourth study (Templin & Vernacchia, 1995) was unsuccessful in using highlight music videos to increase field-goal percentages of college basketball players. The fifth study successfully decreased inappropriate on-court behaviors during tennis matches of college players (Galvan & Ward, 1998).

An additional study (Kearns & Crossman, 1992) encouraged college basketball players to use relaxation and imagery at both practices and games to improve free-throw shooting. Percentage of free throws made showed small improvement at practices for the 3 subjects and a clear improvement during games for 1 subject.

As described in the section on generality of behavior change, six studies intervened at practices, measured performance at practices, and also assessed performance during games or competitions. There was clear evidence of generalization of treatment effects to games in all six studies (Brobst & Ward, 2002; Komaki & Barnett, 1977; Landin & Hebert, 1999; Wanlin et al., 1997; Ward & Carnes, 2002; Ward et al., 1997).

Social Validity

Kazdin (1977) and Wolf (1978) described a number of strategies to help researchers formally address three

questions about their interventions: (a) What do the participants (and perhaps significant others) think about the goals of the intervention? (b) What do they think about the procedures that were applied? (c) What do they think about the results produced by those procedures? Martin and Hrycaiko (1983b) called on researchers in sport psychology to incorporate formal social validity assessments with participants. Of the 40 studies, 26 conducted a formal social validity evaluation with participants, and the results indicated positive reactions to all three of these questions in most instances.

DISCUSSION

Collectively, these studies illustrate the potential of a variety of interventions for improving a variety of athletic behaviors in a variety of sports. Although many of the interventions (e.g., goal setting, publicly posted feedback, contingent praise) were typical of many studies in *JABA*, some of the interventions (e.g., self-talk, imagery, hypnosis) were atypical. There were several impressive aspects of this body of research. First, there was a large number of participants (222 in all). Second, there were clear effects demonstrated in most instances. Third, a wide range of individual and team sports were studied (16 different sports in all). Fourth, the age range of the athletes was considerable, and included preteens, teenagers, and adults. Fifth, there was a wide range in the ability level of the athletes (from beginners to international-level competitors). Sixth, all of the six studies that intervened at practices and measured performance at practices and competitions provided clear evidence of generalization of treatment effects to competitions.

Although aspects of this research are impressive, there are also several limitations. First, the studies included only 2 international-level competitors and no professional athletes. Second, many sports have not been studied (e.g., badminton, bowling, boxing, diving, field

hockey, judo, racketball, skiing, squash, throwing events at track meets, water polo, weight lifting, and wrestling). Third, although functional analysis has become increasingly popular in *JABA* studies, none of the studies included in our review used functional assessment methodology. Fourth, only four of the studies included a formal follow-up phase, and only one study demonstrated a spread of intervention effects to nontargeted performance areas. However, it should be recognized that the lack of intervention effects for nontargeted behavior is not necessarily a limitation. Rather, this may simply reflect good judgment by the researcher in selecting independent behaviors as candidates for controls in a multiple baseline design across behaviors (e.g., see Allison & Ayllon, 1980; Brobst & Ward, 2002).

A comparison of the studies published in sport psychology journals with those published in behavioral journals reveals three interesting differences. First, as indicated in Figure 1, the number of studies published in behavioral journals has remained relatively stable over the past three decades, while the number of studies in sport psychology journals has increased dramatically. Second, the interventions in studies in behavioral journals draw heavily from common behavioral principles and techniques, while some of the interventions (e.g., imagery, hypnosis, highlight music videos) in sport journals are not typical of common behavioral interventions. Third, the studies published in behavioral journals, and especially in *JABA*, typically have large, clear effects. But during the last 11 years, four of the 17 studies published in sport journals had few or no effects (Kearns & Crossman, 1992; Lerner et al., 1996; Rogerson & Hrycaiko, 2002; Templin & Vernacchia, 1995). A fifth study (Ram & McCullagh, 2003) that had few or no effects was not included because it did not meet the first inclusion criterion. One possible explanation of this difference is that some of the researchers

who publish in sport journals may have a different academic history than many of the typical readers of *JABA*. In the first issue of *JABA*, Baer et al. (1968) discussed the importance of a demonstration of experimental control. Later, Baer (1977) described the historical tendency for applied behavior analysts to study large effects, and argued that it was precisely the study of variables that produced large and dramatic effects that enabled applied behavior analysts to develop a powerful technology of behavior. On the other hand, two of the sport researchers who called for increased use of single-subject designs in sport psychology (Bryan, 1987; Wollman, 1986) both suggested that single-subject designs were well suited for studying small effects. Thus, some of the researchers who publish only in sport journals may not have a strong radical behavioral perspective concerning the value of large effects for demonstrating experimental control with a small number of participants. However, one advantage from the tendency of sport journals to accept articles using single-subject designs that report few or no effects is that it provides published data on weak interventions. Such information can be of considerable value for sport psychology consultants (Martin, Vause, & Schwartzman, in press).

An analysis of some of the interventions that are more typical of mainstream work in sport psychology, and less typical of articles in *JABA*, suggests that such interventions might be improved with a behavioral analysis. For example, several studies demonstrated positive effects of self-talk for improving athletic performance (e.g., Hamilton & Fremouw, 1985; Ming & Martin, 1996; Landin & Hebert, 1999; Ziegler, 1987), and one study was judged not to have provided a demonstration of an experimental effect using self-talk (Rogerson & Hrycaiko, 2002). Martin (2003) and Martin and Tkachuk (2000) described several ways that a behavioral analysis might improve the effectiveness of self-talk interventions,

depending on the function that the self-talk is expected to serve. For example, if a young gymnast is encouraged to use self-talk to relax just before performing, then the practitioner might follow guidelines for respondent conditioning of self-talk as a conditioned stimulus for relaxation (Martin). On the other hand, if the self-talk is meant to function as a partial rule (e.g., Ming & Martin), then the practitioner might capitalize on strategies for enhancing rule-governed control over behavior (Martin). To take another example, three studies demonstrated positive effects of a hypnosis intervention (Pates et al., 2002; Pates, Maynard, & Westbury, 2001; Pates, Oliver, & Maynard, 2001). Pates, Maynard, and Westbury suggested that "The hypnosis intervention developed for this study may help performers enter a state where they appear to experience cognitions normally associated with peak athletic performance" (p. 97). There is room for a behavior analysis here. Also, the hypnosis intervention included relaxation, imagery, hypnotic induction, hypnotic regression, and a verbal "trigger." A component analysis is also in order.

An examination of the studies reviewed here leads to numerous areas for future research. For example, many of the studies used packaged interventions and could benefit from component analyses. Miltenberger, Fuqua, and McKinley (1985) identified three practical reasons why it is important for researchers to try to identify the behaviorally active components of a complex multiple component procedure. First, a simple behavior-change procedure is easier to teach to clients and therapists than a complex package is. Second, clients are more likely to comply with simpler treatments than with more complex ones. Third, the identification of the active treatment components in a package may help to clarify the principles responsible for the treatment's effectiveness. One intervention that might benefit from component analysis is the treatment package that combined instructions,

the freeze technique, modeling, and feedback that was researched by Ayllon and colleagues. Fitterling and Ayllon (1983) suggested that the rapidity with which improvements were observed with this package suggested that the skills were generated through the aversive aspects of the freeze technique and were maintained through positive reinforcement. That suggestion deserves experimental analysis. As another example, several studies used a "mental training" package consisting of goal setting, self-monitoring, self-talk, imagery, and feedback. It is not clear that all components contributed to the effectiveness of the package. It is clear that it was time consuming to teach all the components to the participants. Such studies would benefit from a component analysis.

As another example of needed research, Osborne et al. (1990) demonstrated that the addition of visual cues to baseballs resulted in an immediate increase in hitting curve balls. Because of time constraints, however, they did not attempt to fade the visual cues. Future research might examine this and other stimulus control strategies for bringing about rapid improvement in sport skills, and research is needed to assess strategies for gradually eliminating such cues to maintain the skill improvements under natural contingencies. Additional areas for research in behavioral sport psychology were discussed by Martin and Tkachuk (2000).

It is also appropriate to mention that there are some sport psychology interventions that do not appear to be amenable to research using a single-subject design. For example, Martin and Toogood (1997) described a seasonal psychological-skills training program for competitive figure skaters. The program included self-report behavioral checklists to identify areas in need of improvement at the beginning of the season; a variety of goal setting, self-monitoring, and feedback strategies to improve practice performance during the season; and on-site competition strategies to maximize competitive per-

formance. Although aspects of the program were researched using single-subject designs (Hume et al., 1992; Ming & Martin, 1996) and a consumer evaluation of the program by skaters, coaches, and parents was very positive (Martin & Toogood), the complexity and duration of the total program was such that it was not feasible to assess using a single-subject design.

In summary, considerable research has demonstrated the value of single-subject designs for use by sport psychology researchers to assess the effects of interventions on athletic performance at practices and competitions. An increasing number of practitioners are applying behavioral interventions to attempt to improve the performance of athletes (Martin, 2003). Based on the research reviewed, such practitioners can use a number of interventions with the confidence that there have been experimental demonstrations of their efficacy.

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