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The Effects of Stimulant Medication and Training on Sports Competence among Children with ADHD

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Abstract

Objective: The current study examined the relative efficacy of behavioral sports training, medication, and their combination in improving sports competence among youth with ADHD.

Method: Participants included 73 youth (74% male; 81% Hispanic) between the ages of 5 and 12 diagnosed with *DSM-IV* ADHD enrolled in a Summer Treatment Program (STP). The study consisted of a 2 (medication: methylphenidate, placebo) x 2 (sports training: instruction and practice, recreational play) between-groups design and was conducted over a 3-week period during the STP. Sports training was conducted with a novel sport, Badminton, to limit previous sport knowledge and to differentiate it from concurrent sports training that occurred within the STP. Objective and subjective measures of sports skills, knowledge, and behavior were collected.

Results: Results indicated that, relative to recreational play, brief sports training improved observed and counselor-rated measures of sports competence including: sports skills, knowledge, game awareness, effort, frustration, and enjoyment. During sports training, medication incrementally improved children's observed rule following behavior and counselor-rated sportsmanship relative to placebo. In the absence of sports training, medication improved behavior, effort, and sport knowledge.

Conclusions: Training in sports skills and rules produced the largest magnitude effects on sports-related outcomes. Therefore, skills training, rather than medication alone, should be used in conjunction with behavioral intervention to teach sports to youth with ADHD. It is recommended that medication only be used as an adjunct to highly structured sports skills training for youth who display high rates of negative behavior during sports activities.

Keywords

ADHD; Sports Outcomes; Stimulants; Behavior Therapy; Combined Treatment

Attention-deficit/hyperactivity disorder (ADHD) is a common neurodevelopmental disorder characterized by developmentally inappropriate levels of inattention, hyperactivity, and impulsivity (American Psychiatric Association, 2013) that affects up to 10% of children and

adolescents in the U.S. (Visser et al., 2014). The core symptoms of ADHD result in significant impairment across a variety of domains of functioning (Pelham, Fabiano, & Massetti, 2005), with one of the most common being peer relationships (Hoza, 2007; Pelham & Bender, 1982). Children with ADHD tend to have bossy, aggressive, and intrusive interpersonal styles (Pelham & Bender, 1982) and, consequently, an estimated 50–80% of these youth are classified as rejected by their peers (Hoza, Mrug, et al., 2005; Pelham & Bender, 1982). Peer relationship problems in childhood predict a host of negative outcomes later in life including delinquency, substance abuse, and psychopathology (Rubin, Bukowski, & Parker, 1998), and therefore remain a critical intervention target among youth with ADHD.

Recreational play, particularly youth sports activities, is a major setting in which peer relationships are formed and maintained. In order to successfully engage in sports activities, children must learn to cooperate with and support teammates (Fraser-Thomas, Côté, & Deakin, 2005). However, over 35 years of research shows that youth with ADHD struggle with these very skills (Hoza, 2007), perhaps best demonstrated by peer sociometric ratings revealing that youth with ADHD are more than twice as likely as their peers to be chosen last for group activities (Pelham & Bender, 1982). The disruptive and inattentive behaviors of youth with ADHD during recreational activities can also directly impact sports performance and have been associated with more frequent suspensions during game-play (Johnson & Rosen, 2000).

In addition to problems directly resultant of the behavior of ADHD youth, a growing body of literature supports that compared to their typically developing peers, children with ADHD have poorer motor skills (see Kaiser, Schoemaker, Albaret, & Geuze, 2015 for a review), which is also associated with greater peer rejection (Livesey, Lum Mow, Toshack, & Zheng, 2010). Many youth with ADHD exhibit motor deficits including poor balance and coordination, jerky and imprecise movements, and difficulties with object control, which may make it challenging to make movements important for many sports, such as running, jumping, and ball-handling (Harvey et al., 2007; Rommelse et al., 2007; Yan & Thomas, 2002). Thus, problems related to ADHD symptoms and impaired motor performance contribute to poor sports performance. Such poor athletic performance can further increase the likelihood that youth with ADHD will experience peer rejection, as poor athleticism has been linked to reduced popularity and respect from peers (Gross, Johnson, Wojnilower, & Drabman, 1985; Livesey et al., 2010; Lopez-Williams et al., 2005; Weiss & Duncan, 1992). Therefore, improving children's sports competence is an important mechanism by which the peer relationship problems of these youth can be addressed.

Currently, three evidence-based treatments exist for youth with ADHD: stimulant medication, behavioral intervention, and the combination of the two (Evans, Owens, & Bunford, 2014; Fabiano et al., 2009; Greenhill et al., 2002; Pelham & Fabiano, 2008). While a large body of research supports the efficacy of these interventions for improving major impairments of daily life functioning for youth with ADHD (e.g., home behavior, classroom functioning), considerably less research has evaluated the efficacy of these interventions on functioning with peers, especially in regard to sports competence.

Stimulant medication has positive effects on some, but not all, aspects of sports competence among youth with ADHD. It has been well established that stimulants improve the disruptive behavior of youth with ADHD during sports activities, including negative peer-directed behaviors (Greenhill et al., 2002; Pelham et al., 1999; Pelham, Manos, et al., 2005). However, medication effects on overall peer relationship functioning (e.g., sociometric nominations) are far more limited (Pelham & Bender, 1982; Whalen & Henker, 1991), as functioning is not normalized (Hoza, Gerdes, et al., 2005). In regard to motor functioning, stimulant medication improves fine motor skills but has more limited effects on gross motor functioning (Kaiser et al., 2015), which is most relevant for sports performance. For example, Harvey and colleagues (2007) did not find an effect of a moderate dose of methylphenidate (MPH; 0.5mg/kg) on object control or locomotor skills, while Pelham et al. (1990) failed to find effects of both lower (0.3mg/kg) and moderate (0.6mg/kg) doses of MPH on baseball skills. However, medication has been shown to improve some aspects of game awareness (e.g., being ready for the play), but has had limited impact on others, including answering questions pertaining to ongoing game play (Pelham et al., 1990; Reitman et al., 2001). Therefore, while medication may improve behavior and some aspects of attention during game play, it does not have an effect on the actual movements and skills needed to effectively perform during the sport.

In addition to the performance limitations of stimulants, children typically participate in recreational activities during evenings and weekends, when children often take medication holidays in order to attenuate stimulant induced weight loss (Greenhill et al., 2002) and mitigate potential tolerance to stimulants (Fusar-Poli, Rubia, Rossi, Sartori, & Balottin, 2012; Wang et al., 2013). Therefore, medication alone is an insufficient intervention for difficulties that children with ADHD experience when participating in recreational activities.

Psychosocial interventions, including behavioral treatment and skills training, also have a large evidence base in treatment for ADHD. Unlike stimulant medication, such interventions have been shown to be effective in improving specific sports skills, game knowledge, sportsmanship, and gross motor proficiency (Hupp & Reitman, 1999; Hupp, Reitman, Northup, O'Callaghan, & LeBlanc, 2002; O'Connor et al., 2014; Pelham & Hoza, 1996; Reitman, Hupp, O'Callaghan, Gulley, & Northup, 2001; Verret et al., 2012). Additionally, like stimulant medications, behavioral interventions have shown positive effects on game awareness and negative behavior during sports activities (Chronis et al., 2004; O'Connor et al., 2014; Pelham et al., 2014; Pelham, Burrows-Maclean, et al., 2005; Reitman et al., 2001).

The third evidence-based intervention for children with ADHD includes a combination of stimulant medication and psychosocial treatment. One of the advantages of combined treatment is that children may be able to perform equally as well with low doses of both modalities as they would with high doses of either modality. This effect has been shown on disruptive behavior in classroom and recreational settings (Fabiano et al., 2007; Pelham et al., 2014; Pelham, Burrows-Maclean, et al., 2005). However, few studies have directly compared the efficacy of behavioral intervention and medication in improving sports competence. Using a single subject design, Reitman and colleagues (2001) found that while stimulant medication improved game awareness on its own, a token economy was even more effective and the combination of the two treatment modalities was the most effective in

improving game awareness. In a between-groups study, Pelham and colleagues (2000) did not find an added benefit of combined treatment over behavioral treatment on children's abilities to attend to ongoing activities (i.e., game play, group discussions), but did find that combined treatment offered incremental benefit in regard to following activity rules and good sportsmanship. However, using a dose-ranging design, Pelham and colleagues (2014) found that in the presence of behavior modification (BMOD), the incremental benefit of MPH on rule violations and disruptive behavior was limited to a low dose (i.e., 0.15 mg/kg), whereas unimodal MPH treatment required a much higher dose (0.6 mg/kg) to produce equivalent effects. These results provide support for the relative efficacy of behavioral interventions; however, these studies are limited in that none attempted to isolate the effects of medication, sports training, and their combination on the acquisition of new sports skills or knowledge.

The current study aimed to expand these findings in an Summer Treatment Program (STP; Pelham et al., 2010) setting, which uses high intensity BMOD in combination with sports skills training to improve disruptive behavior, peer relationships, and sports competence. The goals of the current study were to evaluate whether, in the context of BMOD, a) stimulant treatment improved sports skills, knowledge, and game awareness, b) sports training improved these outcomes, and c) there was an added benefit of treating youth with ADHD with both modalities.

Method

Participants

Participants were 73 children between the ages of 5 and 12 ($M = 7.99$ years, $SD = 1.70$) diagnosed with *DSM-IV* ADHD who were predominately male (74%) and of Hispanic ethnic origin (80.8%). Diagnoses of ADHD were made according to best-practice recommendations (Pelham, Fabiano, et al., 2005) and included parent and teacher ratings of *DSM-IV* symptoms (i.e., the Disruptive Behavior Disorders Scale; Pelham, Gnagy, Greenslade, & Milich, 1992), a structured parent interview (NIMH Diagnostic Interview Schedule for Children IV, computerized version; Shaffer, 2000), and parent and teacher ratings of cross-situational impairment (Impairment Rating Scale; Fabiano et al., 2006). Two clinicians, who held either a Ph.D. or M.D., reviewed the data to confer diagnoses. If disagreements occurred (less than 1% of cases), a third clinician reviewed the file and the majority decision was used. Forty-four children received a concurrent diagnosis of oppositional defiant disorder (ODD), and 9 participants met criteria for conduct disorder (CD).

Children were excluded based on the following criteria: (1) Full Scale IQ below 80; (2) receiving psychotropic medication for conditions other than ADHD or active medical or psychiatric conditions that could be worsened by stimulants at the time of study enrollment; (3) documented intolerance to MPH medications or a failed trial of sustained release MPH at full therapeutic doses; (4) concurrent diagnosis of *DSM-IV* Autism or Asperger's Disorder, and (5) comorbid conditions requiring psychotropic medication or emergent treatment (e.g., mania, active suicidal ideation).

Two children withdrew from the study due to family relocation ($n = 1$) and the emergence of a comorbid condition that required immediate treatment ($n = 1$). The remainder of participants completed the study. Table 1 summarizes demographic data for the entire sample.

Procedures

Participants were enrolled in a larger study examining tolerance to stimulant medication (MH099030) that was conducted during the 2014 STP (Pelham et al., 2010) at Florida International University. The study was approved by the Institutional Review Board at Florida International University and the Western Institutional Review Board. Parents provided consent for children to participate in the STP, which included daily data collection regarding the child's behavior and performance. Children were referred to the STP by local professionals or schools, media advertisements, billboards, or parent self-referral.

Setting.—The STP is an intensive behavioral intervention for children with ADHD and related problems that focuses on teaching appropriate behaviors, social and problem-solving skills, and sports skills (Pelham et al., 2010). The 2014 STP was conducted on weekdays from 8 AM to 5 PM for 8 weeks. Children were placed in 6 groups of 12 to 14 according to age and supervised by 5 to 7 paraprofessional counselors who were supervised by permanent Ph.D. level staff members. Children spent 2 hr in academic settings and spent the remainder of the day participating in group recreational activities (e.g., art, skills drills, and games). Staff members implemented a comprehensive behavior management system throughout the day that included a point system in which children earned points for appropriate behaviors (e.g., following activity rules, attending to ongoing activities) and lost points for inappropriate behaviors (e.g., violating activity rules, verbal aggression towards peers and staff). The behavior management system also included standard activity rules and procedures, time-out for serious inappropriate behaviors (i.e., aggression, destruction, and repeated noncompliance), and frequent social reinforcement for appropriate behavior (Pelham et al., 2010). As part of their daily STP activities, children participated in a 45-minute recreational period during which the current study was conducted. The study consisted of two between-subjects factors: medication (MPH or placebo) and sports training (training or recreation).

Medication.—During the first two weeks of the STP, children underwent a controlled assessment of up to three different doses of MPH. Based on parent preference, children either received Concerta: 18, 27, and 36mg/day ($n = 63$) or Focalin XR: 5 and 10mg/day ($n = 10$). The lowest dose that produced substantive and incremental efficacy with minimal side effects was prescribed for three weeks during a six-week double blind placebo crossover. Children were prescribed an average daily dose of 21 mg ($SD = 7.8$) or 0.24 mg/kg/dose ($SD = 0.08$). Children were randomly assigned to receive medication ($n = 37$) or a placebo ($n = 36$) for three consecutive weeks including weekends, with crossover for the final three weeks of the STP. Counselors were unaware of medication status. There were no significant group differences on demographic factors between children receiving medication and those receiving placebo.

Sports Training.—During the final three weeks of the STP, groups attended a 45-minute recreation period during which groups were randomly assigned to either receive training in Badminton¹ ($n = 35$) or to play Badminton recreationally ($n = 38$) over 13 days. An uncommon sport was selected for two reasons: (1) to minimize children's previous sport knowledge and experience and (2) to differentiate it from the standard sports played in the STP (i.e., baseball, soccer, and basketball) to minimize the effects of training during these sports for individuals in both groups. STP groups were randomly assigned to training conditions in blocks based on the age of the children in each group. However, age still differed significantly by condition such that children in the recreational condition were slightly older ($M = 8.08$, $SD = 2.19$, range 5–12 years old) than those in the training condition ($M = 7.89$, $SD = 0.93$, range 6–10 years old; $\chi^2(7) = 27.36$, $p < .001$). Therefore, age was entered as a covariate in all analyses.

In the sport training condition, structured skill drills from a youth coaching program (Badminton World Federation, 2011) were alternated with organized games on an every-other-day basis. During skill drill periods, children practiced core Badminton skills, including serving, backhands, underhands, and overheads, in groups of 3 to 5 children led by a staff member. Children practiced three skills per period in a rotating schedule that was determined ahead of time and standard across all groups in the training condition. During game periods, counselors held a 10-minute pre-activity discussion in which sport rules and the application of practiced skills were discussed. In order to maximize playing time for each child while ensuring adequate adult supervision, two games were played simultaneously with 3–4 players per team. Following the game, groups spent five minutes discussing progress and areas for continued development. During both skill drills and game periods, trained counselors coached children on skills and rules and provided positive reinforcement for skill use and demonstration of sports knowledge.

In the recreation condition, children did not receive any sports skills training and only participated in games, which resulted in children in the recreation condition playing games twice as often as those in the training condition. Counselors held 10-minute pre-activity discussions in which counselors emphasized how children could use appropriate social skills during the group activity, but gave minimal information on sports rules. Trained counselors refereed games, but did not provide performance feedback. Following the games, groups spent five minutes discussing problems, progress, and how social skills were used.

In both conditions, counselors asked game awareness questions for which children could earn points. Sample game awareness questions included, "What's the score and who's winning?" and "Who scored the point?" Additionally, all other components of the STP behavior management system described above, including point losses for violating rules of the sport, were employed during both conditions. However, in order to minimize coaching in the recreation condition, counselors in the training condition provided explanations for rule violations (e.g., "You lose 10 points for violating a rule of Badminton because you are

Our initial intention was to conduct training in two sports: Badminton and Newcomb Volleyball. However, on the pre-test day we discovered that Newcomb Volleyball was too easy for the vast majority of children and there was very little variability likely to be affected by treatment. Therefore, only Badminton results are presented herein. Results from Newcomb Volleyball training are available upon request from the first author.

stepping over the service line. The server must remain behind the line.”), whereas counselors in the recreation condition simply informed children of a point loss for violating a rule of the sport without any further explanation.

Treatment and Procedure Integrity and Fidelity.—Staff members underwent an intensive week-long training in the manualized behavioral treatment procedures used during the STP (Pelham et al., 2010; Pelham, Greiner, & Gnagy, 2012). Training also focused on teaching staff members to implement developmentally-appropriate sports training, including development of skill drills to teach sport skills and knowledge, modeling of appropriate sport participation, and reinforcement for effort and mastery of skills. Training included extensive observation of staff members’ skills and frequent performance feedback. To ensure adherence to the behavioral intervention and condition protocols, fidelity observations were conducted on over 30% of sport periods. Observations were conducted by an advanced doctoral student with extensive experience in both STP and study procedures. The observer marked counselors’ adherence to a detailed list of study procedures for both conditions; rated the frequency and quality of coaching, social reinforcement, and game-awareness questions; and rated the overall quality of implementation of study procedures. Frequency ratings were made by tallying each occurrence of counselor behavior. Quality ratings were made according to a Likert scale that ranged from 1 (*Superior*) to 7 (*Inadequate*) and were based on dimensions specific to each domain. For example, coaching quality was rated based on the developmental appropriateness of coaching, proper modeling of skills, and whether feedback was individualized to each child’s skill level. Staff members were given immediate feedback regarding their performance. Treatment integrity and fidelity checklists indicated that 95.35% (range 80 – 100%) of procedures were implemented as intended during game periods and 93% (range 87 – 100%) were implemented during skills periods. Compliance with medication conditions averaged 95%, with children only missing doses on days in which they were sick and/or absent from the summer program.

Sport Competence Measures

Sport competence in this study was defined as possessing the fundamental knowledge and skills necessary to be successful in Badminton. Measures were developed after consulting similar studies (Lopez-Williams et al., 2005; O’Connor et al., 2014) and youth coaching practices (Badminton World Federation, 2011). Pre-tests were conducted prior to the 13-day sport condition and post-tests were conducted 1–2 days after the conclusion of the condition. Children’s medication conditions (i.e., placebo or medication) were matched at pre- and post-test. Measurements were collected and supervised by the first three authors, each of whom was involved in the development of the study methodology.

Sport Skills.—Written protocols that included detailed instructions for equipment set-up, scripts for describing activities to the child, and operationalized coding procedures were developed for each measure of sports skills and are available from the first author. Sports skills were measured in a 1-on-1 testing environment. For each skill, children performed one practice trial, during which the child was given feedback if he or she demonstrated behavior that affected accurate measurement (e.g., stepping beyond the starting line). However, children were not given feedback that could affect performance (e.g., instruction on proper

form). Children were given 6 trials for each skill. A proportion of successful trials over total trials was calculated for each skill.

Badminton Underhands, Backhands, and Overheads.: The child stood on a spot marker in the center of the court, just behind the service line. Before assessing each stroke, the tester demonstrated the appropriate racquet grip and form used for the stroke. The tester then instructed the child to attempt to return the shuttle using the stroke that was demonstrated immediately before the trial began. One tester fed the child shuttles within one arm's length of the child while another tester coded the trial. An attempt was considered successful if 1) the child remained behind the service line and 2) the shuttle successfully crossed over the net and landed within the boundaries of the opponent's court. There were no significant pre-test differences by training or medication condition on this measure.

Badminton Serves.: The child stood on a spot marker behind the service line on the right side of the court. The tester demonstrated a successful serve using the appropriate form. An attempt was coded as successful if 1) the child remained behind the service line and 2) the shuttle successfully crossed over the net and landed within the service boundaries of the opponent's court. At pre-test, children who received medication averaged less than one successful trial out of 6, whereas those who received placebo averaged 1 successful trial out of 6 (Wald: 6.88; $B = 0.82$; $SE = .31$; $p < .01$). Pre-test scores were included as a covariate in analyses.

Sport Knowledge.—Knowledge measures consisted of 10 multiple choice, true-false, or open-ended items to assess the child's knowledge of sport procedures and rules and are available from the first author. A sample item is: "When the sport leader calls a 'let': a) the other team scores a point, b) your team scores a point, or c) there is a "do-over" and neither team scores." A sample open-ended question featured a picture of a court and children were instructed to draw an "X" in the server's position. All test questions and answer choices were read aloud twice. Children were allowed to ask questions to ensure understanding of test items. Mean scores (number correct) were calculated for each assessment. At pre-test, there were no significant differences by training condition on this measure. However, children who received medication ($M = 5.86$, $SD = 1.58$) performed better than those who received placebo ($M = 5.17$, $SD = 1.90$; $F(3, 69) = 4.10$, $p < .05$), perhaps due to better behavior or attention during the oral test. Knowledge pre-test score was included as a covariate in analyses.

Staff Ratings.—Following each condition, STP counselors completed the sport-related items of the Staff Improvement Rating Form (SIRF; Pelham et al., 2000), a rating form designed to evaluate areas of functioning targeted during the STP. Consistent with previous studies using similar measures (e.g., Haas et al., 2011; Pelham et al., 2000), ratings were averaged across counselors. The sport-related ratings ranged from 1 (*very much worse*) to 7 (*very much improved*) and included 3 items pertaining to children's sport skills/abilities, sportsmanship, and sport knowledge in Badminton. Counselors could also indicate "no problem" for any domain in which children did not experience any impairment at the start of the sport condition. If a counselor indicated "no problem" (6% of cases) the rating was

dropped and ratings were averaged amongst remaining counselors. Counselors also rated children's enjoyment, frustration level, and effort exerted during the sport condition. Responses on these items ranged from 0 (*much less than other activities*) to 4 (*much more than other activities*).

Point System Behaviors.—Frequency counts of social behavior were collected as a part of the STP point system. Consistent with past research conducted within the STP (Chronis et al., 2004; Pelham et al., 2014; Pelham, Manos, et al., 2005), the following behavioral categories were derived from the point system: (1) rule violations; (2) game awareness; (3) name-calling/teasing peers; (4) verbal abuse to staff; and (5) complaining. Also consistent with past studies (e.g., Pelham et al., 2014; Pelham, Burrows-Maclean, et al., 2005), independent observers classified and recorded the behaviors of 25% of the children in a group. Observations were conducted over days and across groups for approximately 20% of the available observation periods. Reliability for each behavioral category was determined by computing correlations and mean differences of observed behavior counts between the group counselors and the independent observers across children. Correlations averaged 0.76 across measures (range = 0.62 to 0.83), and mean differences of observed behavior counts ranged from 0.22 to 1.70 across measures.

Results

All analyses were conducted in SPSS 19.0 and included the following predictor variables: medication (medication, placebo), training (training, recreation), medication x training, and child age. Additionally, pre-test scores were included as predictors when applicable (i.e., sports skills outcomes and knowledge). Proportional data (i.e., sports skills outcomes, attention questions) were analyzed using logistic regression models (Atkins & Gallop, 2007). Continuous data (i.e., sport knowledge and counselor-rated outcomes) were analyzed using ANCOVAs. Point system behaviors were analyzed using negative binomial regression models (Coxe, West, & Aiken, 2009). While models were conducted on estimated means and standard errors, raw means and standard deviations for all outcome variables are displayed in Table 2 for ease of interpretation. Estimates of effect sizes (ES) are displayed in Table 3. Effect sizes for count data were estimated using a standardized mean difference, where the BMOD only condition (no training, placebo) served as the comparison. The standard deviation was calculated based on the estimated mean and the distribution (i.e., the alpha dispersion parameter) of the BMOD only condition. Cohen's *d* effect sizes are presented for sport knowledge and counselor-rated items.

Sport Skills

The results displayed in Table 2 show that sports training significantly improved the overall acquisition of Badminton skills ($OR = 0.58$; $SE = 0.17$; $p < .01$) and backhands ($OR = 0.40$; $SE = 0.34$; $p < .05$) relative to no training. Additionally, there was a marginally significant effect on serves ($OR = 0.48$; $SE = 0.44$; $p < .10$). However, there was no effect of training on underhands or overheads. No significant effects of medication or interaction effects were found on the observational measures of sports skills.

Sport Knowledge

Children who received training performed significantly better on the endpoint sport knowledge test relative to children in the recreation condition ($F(3, 66) = 32.79$; $p < .001$; partial $\eta^2 = 0.34$). There was no significant main effect of medication on sport knowledge ($F(3, 66) = 0.33$; $p > .05$). However, there was a significant training by medication interaction such that medication led to improved performance among children in the recreation condition, but not in the training condition ($F(3, 66) = 7.82$; $p < .01$; partial $\eta^2 = 0.11$). Measures of ES indicate that relative to BMOD only, there was a large effect of both sports training ($d = 1.34$) and combined treatment ($d = 1.05$), and a moderate effect of medication ($d = 0.67$) on sport knowledge.

Counselor Ratings

Results displayed in Table 2 demonstrate a significant effect of sports training on nearly all counselor-rated items, including sports skills ($F(3, 69) = 10.18$; $p < .01$; partial $\eta^2 = 0.13$); sportsmanship ($F(3, 69) = 5.57$; $p < .05$; partial $\eta^2 = 0.08$); effort ($F(3, 69) = 6.88$; $p = .01$; partial $\eta^2 = 0.09$); frustration ($F(3, 69) = 44.78$; $p < .001$; partial $\eta^2 = 0.34$); and enjoyment ($F(3, 69) = 19.27$; $p < .001$; partial $\eta^2 = 0.22$). The effect of training on counselor-rated sport knowledge was marginally significant ($F(3, 69) = 3.12$; $p < .10$; partial $\eta^2 = 0.05$). Further, training, both as an adjunct to medication and on its own, had a moderate to large magnitude effect on counselor-rated items relative to BMOD only with Cohen's d values ranging from 0.52 to 1.56 (Table 3).

While training had an effect on nearly all counselor-rated outcomes, only two showed significant improvement with medication. Counselors rated that sportsmanship ($F(3, 69) = 9.90$; $p < .01$; partial $\eta^2 = 0.13$) and effort ($F(3, 69) = 4.48$; $p < .05$; partial $\eta^2 = 0.06$) were improved with medication. Relative to BMOD only, medication had large effects on both of these domains (Cohen's d ranging from 0.71 to 0.74), while Cohen's d values for other items were in the small to moderate range (from 0.36 to 0.49). No medication by training interactions were observed on counselor-rated items.

Point System Behaviors

As displayed in Table 2, there was a significant effect of both sports training and medication on rule violations such that training reduced rule violations by approximately 1.5 violations per 45-minute game period (Wald = 4.17; $B = 0.51$; $SE = 0.25$; $p < .05$) and medication reduced rule violations by 3 violations per period (Wald = 15.28; $B = 1.02$; $SE = 0.26$; $p < .001$). Further, estimates of ES (Table 3) indicate that relative to BMOD only, there was a large effect of medication and a moderate effect of combined treatment. There were no other significant effects of training, medication, or their interaction on disruptive behaviors. However, a trend towards significance was observed for medication on instances of name-calling/teasing peers (Wald = 3.53; $B = 1.92$; $SE = 1.02$; $p = .06$). Compared to BMOD only, ES estimates indicated a large effect of medication on teasing (Table 3).

There was a significant effect of sports training on children's game awareness (Wald = 5.50; $B = -0.69$; $SE = 0.29$; $p < .05$). While an examination of raw means in Table 2 shows little difference between the training and recreation conditions, estimated model means that

accounted for age indicated that children in the training condition answered twice as many attention questions correctly (estimated mean = 0.27, $SE = 0.04$) as did children in the recreation condition (estimated mean = 0.14, $SE = 0.01$). Estimates of ES (Table 3) indicate a small effect of training on game awareness relative to BMOD only. No significant medication or interaction effects were found for game awareness.

Discussion

The current study aimed to examine the relative efficacy of behavioral sports training, medication, and their combination on sports outcomes among youth with ADHD, extending the results of an earlier study examining only medication effects (Pelham et al., 1990) and extending the analysis of behavioral treatment effects and combined treatment effects to improvement in sports competence. Overall, results support that brief sports training in a novel sport improved sports skills, knowledge, game awareness, rule following, and other counselor-rated outcomes such as enjoyment and frustration among children with ADHD. Medication improved children's counselor-rated sportsmanship and effort, as well as children's observed rule following behavior during sports activities. The only outcome for which combined treatment yielded the best outcome was for counselor-rated sportsmanship. Each of these findings will be discussed in turn.

Sports Training

While there are many reports of improvements in behavior and attention during sports activities in the STP (Chronis et al., 2004; Pelham & Hoza, 1996; Pelham et al., 2014; Pelham, Burrows-Maclean, et al., 2005), and one previous randomized controlled trial of the entire STP treatment package on sports outcomes in young children (O'Connor et al., 2014), the current study is the first controlled evaluation to document that the sports training component in the STP produces incremental benefit on sports skills and knowledge in children with ADHD. We found a significant effect of 9 hr of sports training on observed and counselor-rated measures of skill improvement. Our results extend findings of past studies examining the effect of sports training and behavioral intervention on the acquisition of sports skills among youth with ADHD (Hupp & Reitman, 1999; O'Connor et al., 2014) to a much wider age range of children and to a sport with which children had very limited prior familiarity.

Our results show a significant effect of sports training on a test of Badminton knowledge and a marginally significant effect of training on counselor ratings of knowledge gains. Relative to BMOD only, counselor ratings and the knowledge test both indicate a large effect of sports training on sport knowledge (see Table 3). These results add to those of O'Connor et al. (2014), the only other controlled study to examine acquisition of sports knowledge among youth with ADHD, that the sports training component of the STP uniquely contributes to improvements in sports knowledge. We also found that sports training lowered observed activity rule violations by approximately 1.5 violations per 45-minute recreation period, likely due to greater knowledge of sports rules. Although considered a small effect statistically, this finding has clinical relevance. Our results suggest that during a typical 1.5 hr little league practice, sports training may result in at least 3 fewer instances in which a

child with ADHD requires redirection by the coach, reducing not only the negative attention that child receives, but disruptions in game play for the entire team. We also found that sports training improved children's ability to pay attention to the ongoing game, suggesting that knowing more about the sport helped children to be more engaged during game play. This finding is consistent with counselor ratings indicating that children in the sports training condition found Badminton more enjoyable and appeared less frustrated during Badminton activities relative to children in the recreation condition. Similarly, counselors rated that the sportsmanship of children in the training condition improved to a greater extent than those in the recreation condition.

Medication

While effects of sports training were found across dependent measures, the impact of medication on sports functioning was more limited. Medication only outperformed training on counselor-rated sportsmanship and observed behavior. Consistent with several controlled studies documenting that medication reduces rule violations and disruptive behavior among youth with ADHD during sports activities (Pelham et al., 2014; Pelham, Burrows-Maclean, et al., 2005; Pelham, Manos, et al., 2005), we found a large significant effect of medication on observed activity rule violations and a marginally significant effect on observed instances of teasing peers. Similarly, we found a large effect of medication on counselor-rated sportsmanship, while sports training yielded a moderate effect. This finding is consistent with past research conducted in the STP demonstrating a positive effect of medication and BMOD on observed rates of sportsmanship (Pelham et al., 2000). Further, the effect of medication on counselor-rated sportsmanship is likely related to the reductions in disruptive behavior (e.g., teasing peers due to poor performance) and rule violations (e.g., misuse of sports equipment) reported above.

Despite improvements in sportsmanship and behavior, there was no added benefit of medication on counselor ratings of children's frustration and enjoyment. These findings are consistent with past work demonstrating limited effects of medication on children's frustration levels during difficult tasks (Pelham, Waschbusch, Hoza, Pillow, & Gnagy, 2001; Pelham, Hoza, Kipp, Gnagy, & Trane, 1997). However, counselors did rate that children who received medication put forth greater effort while playing Badminton relative to those who received a placebo. Medication has been shown in past studies to improve children's persistence and adult ratings of effort on difficult tasks (Milich, Carlson, Pelham, & Licht, 1991; Pelham et al., 1997). Despite increased effort when taking medication, medication alone was not sufficient to produce improvement in actual sport performance, as there was no significant main effect of medication on the observed or the counselor-rated measures of skill improvement. These findings extend the negative findings of Pelham et al. (1990) to a sport other than baseball and are consistent with those of Harvey et al. (2007), who also found no effect of medication on motor skills important for Badminton such as object control and locomotor skills. Importantly, both Pelham et al. (1990) and Harvey et al. (2007) used higher doses of MPH (0.3 mg/kg/dose and 0.6 mg/kg/dose; and 0.5 mg/kg/dose, respectively) than was used in the current study (0.24 mg/kg/dose). Therefore, we would not expect to find larger medication effects on the sports skills examined in the current study with higher doses of MPH.

Results demonstrate that in the context of BMOD, medication had no effect on children's game awareness, as measured by attention questions (Pelham et al., 2012). While these results are inconsistent with past findings demonstrating added benefit of medication on the on-task behavior (i.e., being in ready position) of youth with ADHD during baseball and kickball games (Pelham et al., 1990; Reitman et al., 2001), they are consistent with past results of attention questions (Pelham et al., 1990, 2000). Again, past studies used higher doses of MPH (e.g., 30 mg/day; Pelham et al., 2000) than was used in the current study (21 mg/day), indicating that higher doses of MPH would not have been likely to produce larger effects on attention.

The current study was the first to examine the effect of medication on the acquisition of new sports knowledge and found that medication did not have a significant main effect on counselor-rated knowledge or the knowledge assessment. Compared to BMOD only, there were large effects of training and combined treatment across knowledge measures and a moderate effect of medication alone (Table 3). Therefore, while there was some impact of medication, the largest improvements were observed when children received sports training.

Combined Treatment

While we found many benefits of combined treatment (i.e., sports training and medication) over medication, there were few benefits of combined treatment over training alone. Specifically, when combined with sports training, there was no added benefit of medication on skills or knowledge measures (Table 2). This is the first study to our knowledge to examine the effect of combined treatment on sports skills and knowledge, and our findings indicate that sports training, not medication, leads to the largest improvements in these domains (see Table 3). However, combined treatment appeared to be the best approach for targeting sportsmanship, as measured by counselor ratings. Combining treatment modalities broadens the range of outcomes affected in certain domains, leading to greater potential treatment gains. In the current study, it appears that medication played a large role in reducing poor sportsmanship behaviors, while coaching around being cooperative and helpful apparently had an added beneficial effect.

Overall, our findings are consistent with those of Pelham et al. (2000), who found that when both sports training and high intensity BMOD were present, medication had little added benefit except on sportsmanship and rule-following. We did not find added benefit of combined treatment on disruptive behavior, likely because high intensity BMOD was present in both training and recreation conditions.

Limitations

The findings of this study must be considered within the context of its limitations. First, BMOD was present in all conditions, potentially limiting the effects of training and medication. The second major limitation was that children in the training condition only received 4.5 hr of training and 4.5 hr of supervised practice distributed over 13 days, significantly less training than children receive over a typical recreation league season or sports camp. The brief training period likely contributed to mixed results on observed skill measures, for which pre-test means were quite low (range 0.08 – 0.18). Therefore, these

tasks may have been too difficult to capture improvements from a brief training program, results that are consistent with past research examining sports skills among youth with ADHD (Hupp & Reitman, 1999; O'Connor et al., 2014). Conversely, counselor ratings in the current study indicated larger effects, suggesting that these measures may have been more sensitive to smaller improvements in skill (e.g., improvements in form despite continued difficulty hitting the shuttle inbounds). Training effects may have also been limited by the expertise of counselors. While counselors were trained in basic Badminton rules and skills and were adherent to study procedures, they were not experts in coaching Badminton.

While it would be expected that more hours of skills training and higher quality of coaching would have yielded larger effects on sports skills and knowledge, larger medication effects over the same extended period would not be expected given the acute nature of stimulant effects (Greenhill et al., 2002). However, higher doses of medication may have yielded larger effects on observed behavior, as the mean medication dose was relatively low (0.24 mg/kg t.i.d.). This dose did produce a large effect on observed rule violations in the current study. Further, past studies have shown that in the context of high intensity BMOD, there is limited added benefit of moderate and high doses (above 0.15 mg/kg t.i.d.) of MPH on behavioral outcomes (Pelham et al., 2014; Pelham, Burrows-Maclean, et al., 2005). Therefore, failure to find medication effects on complaining and verbal abuse in the current study is likely due to the low frequency of these behaviors during the brief 45-minute sports periods, compared with past studies that used full-day behavior totals and found significant medication effects on these behaviors (Pelham et al., 2014; Pelham, Burrows-Maclean, et al., 2005; Pelham, Manos, et al., 2005), rather than the dose of medication employed.

No standardized measures with normative data were available, necessitating the development of novel measures of Badminton skills and knowledge for this study. Sport skill assessments consisted of six trials per skill; it is possible that additional trials may have yielded a greater number of significant effects. Additionally, the study design allowed counselors to be aware of training condition, and resulting greater expectations for improvement in sports outcomes on behalf of counselors in the training condition may have impacted results on counselor-rated measures. In contrast, children's medication status was masked, which may also account partially for the discrepant findings between medication and training condition with respect to counselor ratings. However, sports training still outperformed medication on objective measures of sports competence, including observed sport skill performance and sport knowledge.

Finally, the results of this study may have limited generalizability, as the sample employed was predominately male and Hispanic. We are not aware of any studies that examine ethnicity as a moderator of sports training response among youth with ADHD. However, in the largest clinical trial of ADHD treatment to date (the MTA study; Richters et al., 1995), Hispanic youth responded no differently to behavioral or pharmacological treatments than did Caucasian youth (Arnold et al., 2003), increasing the likelihood that current results will replicate in samples of different ethnic/racial makeup. Generalizability may also be limited in that only one sport was used. However, while not measured directly in the current study, the likely mechanisms by which Badminton skills improved (i.e., hand-eye coordination,

precise timing, footwork), are important for successful performance in many sports. Additionally, the other sports competence measures employed, including learning of sports rules, attention and behavior during game play, and children's effort and enjoyment of game play, can be readily applied sports other than Badminton.

Conclusions and Clinical Implications

Overall, results indicate that relative to medication, sports training results in greater improvements in sports performance and that medication effects were limited to managing behavior and improving behavior-related sportsmanship. Our findings provide support for previous work demonstrating the efficacy of behavioral sports training on improving sports skills, knowledge, and game awareness (Hupp & Reitman, 1999; O'Connor et al., 2014; Pelham et al., 2014; Reitman et al., 2001). Further, our findings on the limited effects of medication on sports performance extend those of Pelham and colleagues (1990) to a sport other than baseball. Our work on the relative efficacy of training and medication supports that of Reitman et al. (2001), demonstrating a larger impact of training relative to medication. Our study also improves upon that of Reitman and colleagues (2001) by using a much larger, between-groups sample, and incorporating both subjective and objective outcomes other than attention. This study adds to the literature documenting that, relative to medication, sports training provides a large improvement on sports skills and knowledge, with little added benefit of combined treatment.

The current study also adds to a growing body of literature documenting the efficacy of the STP as a treatment package. While many studies have demonstrated the relative efficacy of the STP to no treatment and to medication (Chronis et al., 2004; O'Connor et al., 2014; Pelham et al., 2014; Pelham, Burrows-Maclean, et al., 2005), this is the first study to directly manipulate the sports skills training component of the STP and demonstrates that this component produces added benefits on sports skills and knowledge over and above those produced by the disruptive-behavior focused behavior management program.

Given the very limited effects of medication on sports outcomes and the beneficial effects of sports training (even over a brief period), combined with other literature demonstrating the effectiveness of sports training (Hupp & Reitman, 1999; O'Connor et al., 2014), sports training should be used to teach sports skills to youth with ADHD and/or as part of peer relationship focused interventions for these youth, as traditional clinic-based social skills training programs are ineffective (Evans et al., 2014; Pelham & Fabiano, 2008). Sports training led to development of sports skills, knowledge, and enjoyment, and less frustration among youth with ADHD. Success in these domains is likely to encourage youth with ADHD to continue participating in sports activities, providing additional opportunities for youth with ADHD to develop sports competence, fitness, and improved peer relationships.

Because medication improved rule following, our results suggest that medication can be a useful adjunct to behavioral sports training for children who exhibit high levels of inappropriate behavior during sports activities. While the current study did not include a no BMOD condition, past research conducted within the STP indicates that in the presence of highly structured training and BMOD, a low dose of medication (employed in the current study) is sufficient in managing behavior for most youth with ADHD whereas higher doses

will be necessary in the absence of behavioral intervention (Pelham et al., 2014; Pelham, Burrows-Maclean, et al., 2005).

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Table 1

Sample Characteristics

Age <i>M</i> (<i>SD</i>)	7.99 (1.70)
Gender (% Male)	74.0
Ethnicity (%)	
Hispanic	80.8
Non-Hispanic	11.0
Did not respond	8.2
Race (%)	
White	87.7
Black	13.7
Other	1.4
Highest Parental Education (%)	
Less than high school	6.8
High school or GED	5.5
Partial college	23.3
Associate's degree	15.1
Bachelor's degree	23.3
Graduate training or degree	26.0
Estimated Full-Scale IQ <i>M</i> (<i>SD</i>)	95.19 (12.01)
ADHD Diagnosis (%)	
ADHD - PI	20.5
ADHD - HI	2.7
ADHD - C	76.7
ODD	60.3
CD	12.3

Note. n = 73

Table 2

Means and Standard Deviations for Outcome Variables

	Training Condition			Recreational Condition			Significant Effects
	Total (N = 35)	Placebo (N = 17)	MPH (N = 18)	Total (N = 38)	Placebo (N = 19)	MPH (N = 19)	
Observed Sport Outcomes							
Total Skills ^a	0.29 (0.16)	0.29 (0.19)	0.29 (0.13)	0.25 (0.22)	0.24 (0.20)	0.27 (0.24)	T ^{**}
Serves ^a	0.47 (0.27)	0.43 (0.22)	0.52 (0.32)	0.40 (0.27)	0.41 (0.34)	0.39 (0.36)	T [†]
Backhands ^a	0.26 (0.26)	0.21 (0.26)	0.31 (0.25)	0.18 (0.24)	0.18 (0.24)	0.18 (0.24)	T [*]
Overheads ^a	0.18 (0.23)	0.22 (0.26)	0.15 (0.21)	0.19 (0.24)	0.15 (0.23)	0.23 (0.26)	TxD [†]
Underhands ^a	0.23 (0.27)	0.30 (0.35)	0.17 (0.15)	0.22 (0.25)	0.22 (0.21)	0.23 (0.30)	
Sport Knowledge ^b	8.75 (1.27)	9.00 (1.26)	8.50 (1.26)	7.32 (1.79)	6.74 (2.02)	7.89 (1.32)	T ^{***} , TxD ^{**}
Counselor Rated Outcomes							
Sport Skills/Abilities ^c	5.26 (0.41)	5.22 (0.46)	5.29 (0.36)	4.88 (0.58)	4.76 (0.55)	5.00 (0.60)	T ^{**}
Sportsmanship ^c	4.61 (0.65)	4.38 (0.67)	4.83 (0.56)	4.23 (0.79)	3.98 (0.86)	4.52 (0.62)	T [*] , D ^{**}
Sport Knowledge ^c	5.31 (0.39)	5.30 (0.36)	5.33 (0.43)	5.10 (0.64)	4.94 (0.63)	5.25 (0.63)	T [†]
Effort ^d	2.26 (0.33)	2.23 (0.31)	2.30 (0.36)	2.04 (0.44)	1.88 (0.48)	2.19 (0.35)	T [*] , D [*]
Frustration ^d	1.94 (0.34)	1.89 (0.31)	1.98 (0.38)	2.42 (0.37)	2.40 (0.38)	2.45 (0.37)	T ^{***}
Enjoyment ^d	2.09 (0.26)	2.11 (0.21)	2.07 (0.31)	1.70 (0.45)	1.62 (0.39)	1.78 (0.50)	T ^{***}
Point System Behaviors ^e							
Rule Violations ^f	3.83 (3.12)	5.73 (3.18)	2.04 (1.73)	5.26 (4.92)	6.69 (6.26)	3.83 (2.49)	T [*] , D ^{***}
Name Calling/Teasing ^f	0.25 (0.46)	0.43 (0.61)	0.07 (0.11)	0.50 (0.96)	0.67 (1.30)	0.32 (0.96)	D [†]
Verbal Abuse to Staff ^f	0.20 (0.31)	0.21 (0.24)	0.19 (0.36)	0.32 (0.56)	0.38 (0.60)	0.27 (0.52)	
Complaining ^f	0.77 (1.44)	1.01 (1.90)	0.55 (0.79)	0.51 (0.82)	0.66 (1.04)	0.36 (0.55)	
Attention ^a	0.58 (0.22)	0.62 (0.20)	0.54 (0.23)	0.58 (0.18)	0.58 (0.16)	0.58 (0.19)	T [*]

Note. T = Training; D = Drug; TxD = Training by Drug interaction[†].

^bOutcomes are proportions of correct trials over total trials.

^gMeasure consisted of 10 items, total number correct is presented.

^cItems consisted of a 1 – 6 scale in which 1 = *much worse* and 6 = *very much improved*.

^dItems consisted of a 0 – 4 scale in which 0 = *much less* and 4 = *much more*.

^eOutcomes are average behavior rates per 45-minute recreational period.

^fOutcomes are count variables.

 $p < .001$.

**
 $p < .01$.

*
 $p < .05$.

†
 $p < .10$.

Table 3

Estimated Treatment Effect Sizes

Measure	Combined Treatment	Training Alone	Medication Alone
Sport Knowledge	1.05	1.34	0.67
Counselor Rated Outcomes			
Sport Skills/Abilities	1.14	0.91	0.42
Sportsmanship	1.17	0.52	0.71
Sport Knowledge	0.71	0.72	0.49
Effort	0.99	0.87	0.74
Frustration ^a	1.11	1.47	-0.13
Enjoyment	1.28	1.56	0.36
Point System Behaviors			
Rule Violations (alpha = 0.532) ^b	-0.44	-0.08	-0.85
Teasing Peers (alpha = 2.84) ^b	-0.38	-0.34	-0.81
Verbal Abuse to Staff (alpha = 2.22) ^b	0.01	-0.09	-0.18
Complaining (alpha = 2.35) ^b	0.19	0.20	-0.28
Attention (alpha = 1.88) ^b	0.24	0.34	-0.02

Note. Treatments were compared to the no training, placebo condition.

^aPositive values reflect lower frustration ratings.

^bPositive values reflect higher rates of behavior.