Therapeutic Effects of Yoga for Children: A Systematic Review of the Literature

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Purpose: We completed a systematic review of the literature on the effect of yoga on quality of life and physical outcome measures in the pediatric population. We explored various databases and included case–control and pilot studies, cohort and randomized controlled trials that examined yoga as an exercise intervention for children. **Summary of Key Points:** Using the Sackett levels of evidence, this article reviews the literature on yoga as a complementary mind–body movement therapy. We address the research through three practice patterns according to the Guide to Physical Therapist Practice and provide considerations for the inclusion of yoga into clinical practice. **Statement of Conclusions and Recommendations for Clinical Practice:** The evidence shows physiological benefits of yoga for the pediatric population that may benefit children through the rehabilitation process, but larger clinical trials, including specific measures of quality of life are necessary to provide definitive evidence. **(Pediatr Phys Ther 2008;20:66–80)** *Key words: adolescent, child, complementary therapy, exercise movement techniques, human movement system, review article, yoga*

INTRODUCTION

By the summer of 2006, "Kid Yoga" camps were appearing on every corner,[1] rivaling lemonade stands and soccer camps in popularity. In April 2007, a search on the Internet with the terms "yoga and children" yielded close to 6,120,000 hits.[2] The Internet offers an abundance of certifications designed for teaching yoga to children.[3] Further, almost every yoga studio in the country now offers classes for young children.[4] Indeed, yoga has now penetrated popular culture for all age groups. As experts in movement analysis and therapeutic exercise, physical therapists (PTs) hold the professional responsibility of determining the value of yoga's age-old art in modern day practice.

Today's "typical child" is described as stressed out,[5] under nourished,[6] and sedentary.[7] The complexity posed by these profiles demands treatment that taps into both the physical and the psychosocial domain. A study by Parshad[8] found the state of the mind and that of the body to be intimately related. If the mind is relaxed, the muscles in the body will also be relaxed. Stress produces a state of physical and mental tension. Yoga, developed thousands of years ago, is recognized as a form of mind–body medicine. There are many forms of yoga with emphasis on various aspects of body mechanics, fitness, and spirituality (Table 1).

Parshad's study demonstrates that yoga's physical postures and breathing exercises improve muscle strength, flexibility, blood circulation and oxygen uptake, and hormone function. In addition, Parshad found that relaxation induced by meditation helps to stabilize the autonomic nervous system with a tendency toward parasympathetic dominance. Physiological benefits that follow help individuals who practice yoga to become more resilient to stressful conditions and reduce a variety of important risk factors for various diseases, for example, cardiorespiratory diseases.[8]

Yoga shows promise as a new modality for the pediatric population. Despite its popularity in popular culture, careful examination of the research is necessary when integrating this modality in traditional pediatric rehabilitation settings. The purpose of this systematic review is to explore the evidence related to the effectiveness of yoga with respect to the practice patterns in the *Guide to Physical Therapist Practice*.[9] We have classified the articles under

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TABLE 1
Different Schools of Hatha Yoga Commonly Practiced in the United States

School	Focus	Description
Ananda	Enlightenment	Tool for spiritual growth while releasing unwanted tensions. Uses silent affirmations while holding a pose as a technique for aligning body, energy, and mind. Series of gentle poses designed to move energy upward to the brain, preparing the body for meditation
Anusara	The Heart	Founded by John Friend in 1997, anusara yoga integrates the celebration of the heart, universal principles of alignment, and balanced energetic action in the performance of asana. Anusara (pronounced ah-new-SAR-ah) means "following your heart." In this school of yoga, each student's abilities and limitations are deeply respected and honored. Source: Lark, Liz. Yoga for Life. Carlton Books, London; 2001
Ashtanga/Power Yoga	Fitness	Athletic; Fast Paced and nonstop; not recommended for beginning students. At the core is linking the breath with each movement throughout the practice. Power Yoga is a derivative, using a more creative sequence of postures
Bikram/Hot Yoga	Healing	Athletic; Practiced in a room heated to 100+ degrees, thus "Hot" Yoga. Sauna-like effect helps move the toxins out of the body
Hatha Yoga/"Yoga"	Holistic	A major branch of yoga, developed by Goraksha and other adepts c. 1000 CE, and emphasizing the physical aspects of the transformative path, notably postures (asana) and cleansing techniques (shodhana), but also breath control (pranayama). SOURCE: "Hatha Yoga." Accessed on September 14, 2007. Available at: http://www.yogajournal.com/newtoyoga/159.cfm
Integral	Enlightenment	Aimed at helping people integrate yoga's teachings into their everyday work and relationships. Incorporates guided relaxation, breathing practices, sound vibration (repetition of a mantra or chant), and silent meditation
Iyengar	Detail	Technical yoga, an intense focus on the subleties of each posture; great for beginning students. Strong focus on precise muscular and skeletal alignment; emphasizes therapeutic properties of the poses. Poses (especially standing postures) are typically held much longer than in other schools of yoga to focus on alignment. Use of props (belts, chairs, blocks, and blankets) to accommodate special needs such as injuries or structural imbalances
Kripalu	Healing	Therapeutic; gentle and spiritually focused; great for beginning students. Incorporates inner focus and meditation within the yoga poses. Focus on alignment, breath, and the presence of consciousness. Holding of the postures to the level of tolerance and beyond. Deepens concentration and focus of internal thoughts and emotions
Kundalini	Enlightenment	Dynamic; Esoteric; Energizing; Aimed at invoking dormant spiritual energy at the base of the spine. Incorporates breath-work, movement, postures, chanting, and meditating on mantras
Sivananda	Enlightenment	Traditional approach; can become very advanced. Rigid class structure of poses, breath-work, meditation, and relaxation. Emphasizes 12 basic postures to increase strength and flexibility of the spine. Focus on proper pose, breathing, relaxation, and diet (vegetarian), and positive thinking and meditation
Tantra	Sensuality	Perhaps the most misunderstood yoga style, tantra is not about sexual indulgence. Rather, it is about discovering and stimulating sensual spirituality. This yoga works with the highly charged kundalini energy and, therefore, should always be guided and taught by a teacher. Tantra teaches practitioners how to use this energy for sexual pleasure, for bringing joy and wholeness to everyday life, and for aiding in spiritual evolution. Tantra yoga includes visualization, chanting, asana, and strong breathing practices. Source: Lark, Liz. Yoga for Life. Carlton Books, London; 2001
Viniyoga	Healing	Therapeutic; repetitious movements in and out of a posture. Individualistic; poses are synchronized with the breath in sequences determined by the needs of the practitioner. Highly adaptable, thus good for students with physical injuries or limitations

the following headings: neuromuscular, cardiopulmonary, and musculoskeletal according to their focus. As reviewers, we feel that the practice of yoga encompasses all three of these practice patterns. However, for the purpose of this review, we have assigned each article to the most pertinent practice pattern according to the focus of each study.

METHODOLOGY

We searched the following electronic databases through January 2007: Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, CINAHL, PsychINFO, and PEDro. The yoga register maintained by the Cochrane Breast Cancer Group was also explored. We used search terms related to yoga and pediatrics (children, developmental disabilities), exercise (eg, exercise, physical activity, cardiorespiratory fitness), and publication type (eg, cohort, case–control, clinical trial). This search strategy was modified as necessary for each database. Appropriate non-English language publications were not found. Of the studies we found pertinent to review, four were published in the 1980s, 10 in the 1990s, and 10 from 2000 to the present.

Studies were considered eligible for inclusion if they were pilot in nature, cohort, case–control, or a randomized clinical trial (RCT). An RCT is an experimental study in

which a clinical treatment is compared with a control condition, where subjects are randomly assigned to groups,[10] and in our review, we compared exercise with a placebo, controlled comparison, or standard care. For the purposes of the review, yoga includes a combination of breathing exercises (pranayama), physical postures (asanas), and meditation (spirituality).[11–13]

Yoga was defined as a form of leisure-time physical activity that was performed on a repeated basis during an extended period of time, with the intention of improving fitness, performance, or health.[14] Table 1 outlines the breadth of yoga styles, some of which were used in the reviewed studies. Studies with an additional treatment arm or combined intervention (eg, yoga with traditional exercise) were included only if the effects of exercise could be isolated. A priori, we excluded reports that were available only in abstract form.

Trials were included only if they involved normally developing children and children with various impairments of the muscular, cardiopulmonary, or neuromuscular systems. Studies were required to have as a primary outcome quality of life (QOL), cardiorespiratory fitness or physical functioning. Secondary outcomes of interest included cognition and attention. We also extracted data on adverse events resulting from the yoga intervention.

Three independent reviewers (R.G., L.Q., and M.L.G.) screened the titles and abstracts of identified studies for eligibility. When one of us deemed an article to be potentially relevant, we obtained the full text and all three reviewers assessed it for inclusion. Information on patients, methods, interventions, outcomes, and adverse events were extracted from the original reports by the three independent reviewers onto paper forms that they had designed and pretested. Kappa coefficient of the reviewers was substantial ($r = 0.60–0.75$) between the three raters. Disagreements were resolved by consensus (R.G., L.Q., and M.L.G.). The methodological quality of each study was assessed using the following criteria[15,16]:

1. Was there adequate concealment of allocation?
2. Was the method of randomization well described and appropriate?
3. Was the outcome assessment described as blinded or unblinded?
4. Was the method of blinding of the assessment of outcomes well described and appropriate?
5. Was there a description of withdrawals and dropouts?
6. Was there intention-to-treat analysis?
7. Were withdrawals and dropouts less than 10%?
8. Was adherence to the exercise intervention (attendance or completion of exercise session) greater than 70%?

All items were scored using Sackett levels of evidence.[17] Studies were defined as being of "high quality" if they fulfilled four or more of the eight quality criteria. We included all the studies in this review, given the paucity of yoga research in pediatrics. Of the 24 total studies identified, five were classified as level 4, four as level 3, 15 as level 2, and none with level 1 grade of evidence. Based on our criteria for evaluation, using both methods, we found few articles that included our criteria for high quality. Although description of randomization was clear throughout all studies, we have little data that describe outcome assessments with regard to the method of blinding, no information on intent-to-treat analysis, and what happened to withdrawals and dropouts. Therefore, studies were of moderate to low quality and require future investigations that incorporate all aspects of a rigorous clinical plan for recruitment, retainment, blinding, and adherence.

NEUROMUSCULAR EFFECTS OF YOGA

Six of the 10 articles assigned to the neuromuscular practice pattern were assessed as 2B grade for levels of evidence, while four additional articles were grade 4. Much variability was noted in the duration of yoga interventions and it is unclear how issues of bias were addressed. Although a trend is noted in improvements of motor planning, performance, and mental and social acuity, further research is needed to incorporate yoga as a definitive modality for the neurologically involved child.

Yoga seems to have a positive impact on motor performance in children and most studies have been conducted on children developing typically (Table 2). Four studies analyzed the effects of yoga on reaction time, planning, execution time, and motor speed.[18–21] Reaction time has been used to quantify level of motor function, and thus speaks to the overall functioning of the central nervous system (CNS).[22] Pilot data by Bhavanani et al[18] found that mukh bhastrika yoga (bellows type breathing) produced decreased visual reaction time and auditory reaction time in 22 healthy schoolboys. This indicates potentially improved sensory-motor performance and enhanced processing ability of the central nervous system.[18] Another pilot study by Manjunath et al[19] showed trends of improved planning and execution times in the yoga group in the Tower of London test for both simple and complex tasks. The Tower of London test is standardized and addresses executive functions. The study revealed no change in the physical training group.

Motor speed, like reaction time, is also a quantification of CNS processing. Dash et al[20] analyzed the effects of yoga training on a finger tapping task, to assess motor speed in children and adults versus a control group of 38 adults. Findings included significant increases in tapping speed values after 10 days of yoga training in the children's group and 30 days of yoga training in the adult group. Although not verified by diagnostic imaging, this and other studies point to the potential plasticity of the brain and CNS in response to yoga. Another study by Telles et al[21] supports improved motor performance in children after yoga training. This study of 90 children ages 9 to 13 years used a steadiness test that required the insertion of and holding of a metal stylus into holes of decreasing sizes. The yoga group showed a significant decrease in errors, while the control group showed no change. Although an

TABLE 2

Neuromuscular Evidence

No.	Study	1st/2nd Reviewer	Features	Participants	Intervention	Endpoints	Summary	Evidence Level
1	Bhavanani et al[18]	MLG/LQ	To determine auditory and visual reaction time with specific yogic breathing.	22 healthy school boys (13–16 yrs).	Trained yoga participants recruited for this study—able to perform mukh bhastika properly—were measured before and after nine rounds of breathing.	Auditory and visual reaction time via computer.	Decreased reaction time noted; this indicated improved sensory-motor performance and enhanced processing of CNS.	4
2	Dash and Telles[20]	LQ/RG	Assess the effects of yoga training on finger tapping speed (as a measure of motor speed).	53 adults and 152 children (categorized according to age and gender) before and after yoga training and 38 adults of a nonyoga (control) group.	Yoga group received yoga training (physical, mental, intellectual, and spiritual) for ~8 hr/day for 10 days for the children and 30 days for the adults.	There was a significant increase in baseline tapping speed between 0 and 10 sec, 10–20 sec, and 20–30 sec in both adults and children after 30 and 10 days of yoga, respectively. However, for both groups at baseline and final assessments, 10–20 sec and 20–30 sec were significantly lower than 0–10 sec.	Increase in motor speed for repetitive finger movements following yoga training, but not in strength or endurance, as the increase was not sustained over 30 sec.	2B
3	Harrison et al[26]	RG/MLG	Effects of meditation as a family treatment method for children with ADHD, using the techniques of Sahaja Yoga Meditation.	47 Children (ages 4–12 yrs) with the diagnosis of ADHD made by a pediatrician or a child psychiatrist (majority of children were receiving medication).	6-week program of twice weekly clinic sessions (90 min) and regular meditation at home (for children and parents.	3 sources of data collection: child self-report questionnaires (Burnett), parent rated questionnaires (Conners and CPRS), and examiner testing/interview (Peabody picture/vocabulary test).	Sahaja yoga meditation has potential as a promising therapy for children with ADHD when offered via a family treatment approach and used in combination with existing medical RX.	2B
4	Jensen and Kenny[25]	RG/MLG	Evaluate the use of yogic exercises as a complementary and alternative medicine (CAM) to pharmacological therapy in reducing the behavioral and attentional deficit symptoms of ADHD in boys.	19 boys (8–13 yrs) with ADHD (diagnosis made by specialist pediatricians) and stabilized on meds (11 in experimental group, 8 in control group).	20 weekly 1 hr yoga group sessions 20 or control ("cooperative activities").	Significant improvements found for yoga on 5 of the Conners' Scales. Significant improvements were found in control group for 3 or the Conners' scales. Data measured with ANOVA.	This data does not provide strong support for use of yoga for ADHD, particularly because study was underpowered, but suggests yoga has merit as a CAM for this population.	4
5	Manjunath and Telles[28]	RG/MLG	Study conducted to determine if yoga training and creative activities that activate the R hemisphere (fine arts) may affect memory positively.	60 elementary school students (aged 11–16 yrs) with attention problems volunteered to participate in this investigation. 30 children attended a yoga camp and the other 30 a fine arts camp.	Yoga camp: 8 hr a day for 10 days. (camp also included games and story telling).	The group trained in yoga showed a significant increase in spatial memory test scores (43% increase), while verbal memory test scores remained the same in all of the children. (multivariate and Tukey test).	This demonstrates that yoga practice improves delayed recall of spatial info.	2B

(Continued)

TABLE 2
Continued

No.	Study	1st/2nd Reviewer	Features	Participants	Intervention	Endpoints	Summary	Evidence Level
6	Manjunath and Telles[19]	LQ/RG	Assess the performance in the Tower of London test at the beginning and end of a month of yoga training.	20 girls (ages 10–13 yrs) studying at a residential school.	Random assignment to 2 groups: one group practiced yoga for 1 hr 15 min/day, 7 days/wk for a month, while the other group was given physical training for the same time.	The yoga group showed a significant reduction in planning time for both 2-moves and 4-moves tasks, execution time in both 4-moves and 5-moves tasks, and in the number of moves in the 4-moves tasks. The physical training group showed no change.	Yoga training for a month reduced the planning and execution time in simple as well as complex tasks and facilitated reaching the target with a smaller number of moves in a complex task.	4
7	Naveen et al[29]	RG/MLG	Since hemispheric memory functions are also known to be lateralized, the study assessed the effects of uninostril breathing on performance in verbal and spatial memory tests.	School children (N = 108) whose ages ranged from 10–17 yrs were randomly assigned to 4 groups. Each group practiced a specific yoga breathing technique. An age-matched control group of 27 were similarly assessed.	Each of 4 groups practiced a specific yoga breathing technique: (1) right-nostril breathing, (2) left nostril breathing, (3) alternate nostril breathing or (4) breathe awareness without manipulation of nostrils. These techniques were practiced for 10 days, 4 times a day, 27 rounds each time. Verbal and spatial memory was assessed initially and after 10 days.	All 4 trained groups showed a significant increase in spatial test scores at retest. Average increase in spatial memory scores for the trained groups was 84%.	It appears that yoga breathing increases spatial rather than verbal scores, without a lateralized effect.	2B
8	Peck et al[27]	RG/MLG	Investigate the effectiveness of yoga for improving time on task with 10 elementary school children who evidenced attention problems.	10 elementary school students with attention problems (aged 6–10 yrs) across 3 grade levels volunteered to participate. Initially, they were recruited by school psychologist. These students were not diagnosed with ADHD, but documented to be "on task" <80% of the time.	A yoga videotape, published by Gaiam, was used that required the children to follow an adult instructor and three children who engaged in deep breathing, physical postures, and relaxation exercises for 30 min, twice a week, for a period of 3 weeks.	Study was a multiple baseline design. Time on task was defined as the percentage of intervals observed that the students were orientating toward the teacher or task, and performing the requested classroom assignments. The results indicated effect sizes that ranged from 1.5 to 2.7 as a function of the intervention. Effect sizes at follow-up decreased, but ranged from 0.77 to 1.95. Peer comparison data indicated that classmates' time on task remained essentially unchanged throughout the three phases of the study.	Peer comparison data indicated that classmates' time on task remained essentially unchanged throughout the three phases of the study.	4

(Continued)

TABLE 2
Continued

No.	Study	1st/2nd Reviewer	Features	Participants	Intervention	Endpoints	Summary	Evidence Level
9	Telles et al[21]	RG/MLG	Determine the effect of yoga on static motor performance in children. Each group was assessed on a steadiness test at the beginning and end of the study.	Two groups of 45 children each, (aged 9–13 yrs).	For 10 days, one group received training in yoga (asanas, pranayama, maintenance of silence, visual focusing exercises, and games to improve attention span and memory), while the other group carried out their usual routine.	After 10 days, the yoga group showed a significant decrease in errors on the steadiness test, whereas the "control group" showed no change.	Children engaged in the yoga program displayed improvement in static motor performance.	2B
10	Uma[30]	RG/MLG	To study the effect of yoga on children with MR of mild, moderate, and severe degree in with respect to IQ and social adaptation parameters.	90 children selected from four special schools (45 students in yoga training group compared to 45 students who continued their usual school routine).	Experimental group underwent yogic training for 1 academic year (5 h in every week) with an integrated set of yogic practices.	Highly significant improvement in the IQ and social adaptation parameters in the yoga group as compared to the control (paired *t* test).	This study shows the efficacy of yoga as an effective therapeutic tool in the management of children with MR.	2B

improvement in the quality of research design, further investigation is needed for application in children with disabilities.

Other studies suggest that yoga increases working efficiency,[23] and overall ability to concentrate and focus.[24] Yoga fosters relaxation and breathing[7] in a very active way, enabling children to channel their energy into goal-driven tasks. These findings have implications for learning and classroom behavior. Three studies specifically examined the use of yoga and meditation as a treatment for attention deficit hyperactivity disorder (ADHD) and would be considered pilot in nature. One study by Jensen et al[25] showed both groups with improvements in several measurement scales with yoga participants improving significantly in the five subscales of the Parents Rating Scales (CPRS). The second study (Harrison et al)[26] incorporated the entire family and measured treatment outcomes. A classroom-based study by Peck et al[27] found yoga to improve time on task in 10 elementary school children evidencing attention problems. Although these data do not provide strong support for the use of yoga for ADHD, partly because the studies are under-powered, they do suggest that yoga may have merit as a complementary treatment for ADHD already stabilized on medication. Yoga remains an investigational treatment, but this study supports further research into its possible uses to address behavioral challenges for this population. These findings need to be replicated on larger groups with a more intensive supervised practice program.

Two studies suggest that academic learning of children developing typically may be further enhanced by memory improvements afforded by yoga. In one of these studies, Manjunath et al[28] compared performance of 90 subjects in verbal and spatial memory tests. Thirty subjects were in one of three groups: yoga camp, fine arts camp, or control group. Members of the yoga group showed a 43% improvement in spatial memory test scores, while the fine arts and control groups showed no change. Subjects in the yoga camp also engaged in game playing and story telling. However, we found it compelling that this group still showed improvement over the fine arts camp group, who most likely also participated in similar social activities. A second study by Naveen et al strengthens the use of yoga for spatial memory scores. In this study, 108 school children aged 10 to 17 years were divided into four groups, each practicing in a different type of yoga breathing.[29] All four groups evidenced improved spatial memory scores by an average of 84%. Verbal memory scores were also measured in both these studies, and seem to remain unchanged after the interventions.

Application of yoga for children with mental retardation also shows promise. Uma et al[30] demonstrated significant improvements in IQ and social parameters compared with a control group through an intervention for 1 academic year. Changes occurring at the neuromuscular level enabled the more global effects of behavioral and cognitive enhancements. Such benefits may be applied along the spectrum of children with neurological impairments but further RCT are needed to determine definitive use of yoga.

CARDIOPULMONARY EFFECTS OF YOGA

Ten articles were reviewed in the cardiopulmonary practice pattern. Seven of the 10 reviewed articles were classified as level 2B, two as level 3B, and one as level 4 (Table 3). Although the quality of evidence was varied, we considered all the articles enriching to our discussion. These studies reveal that yoga may be used with typical children, and with physically or emotionally impaired children to improve cardiorespiratory parameters. Further, these studies also demonstrate that the processes initiated by yoga practice can have an impact on the more global issues of socialization and stress management. It is important to note that physical impairments are often heavily influenced by psychosocial factors. Therefore, PTs may consider yoga as an adjunct for pediatric cardiopulmonary rehabilitation.

A primary emphasis in the practice of yoga is controlled-breathing techniques. This idea leads to new research on children with cardiopulmonary impairments. Our search yielded four studies that demonstrate yoga's mechanism of action on subjects with healthy cardiac function. First, a study by Udupa et al[31] analyzed the effects of pranayama training (voluntary regulation of breathing) on cardiac function in normal young volunteers. Twenty-four school children were divided into a pranayama group and a control group. The pranayama group practiced breathing techniques for 20 minutes daily for 3 months. A control group maintained normal breathing. Researchers found that pranayama training effectively modulated ventricular performance by decreasing sympathetic output and thereby increasing parasympathetic output. This study provided baseline evidence for the efficacy of yoga on cardiorespiratory parameters in normal volunteers, and allowed for expanded research into populations with pathology.

Three additional studies examined the effects of yoga on volunteers with normal cardiac function who also had anxiety. Such studies are important in that they implicate psychosocial issues as contributors to autonomic impairments. This idea was supported by Telles et al[32] in a study on physically normal but socially or emotionally traumatized girls. In their study the researchers randomly selected 40 girls between 12 and 16 years of age from a total of 120 girls in a community home. All subjects had a history of adjustment difficulties either at home or in society. The study aimed to determine differences in autonomic and respiratory parameters between these girls and those of the same age living at home and attending a regular school. The community home group was found to have significantly higher breath rates, more irregular breathing patterns, and lower skin resistance values than their age-matched peers. These attributes are known to correlate with fear and anxiety.[33,34] Additionally, the study aimed to compare the effects of two interventions—yoga and games—on the same physiologic measurements. For an hour daily over a 6-month period, half of the community home girls engaged in relaxing yoga, while the other half engaged in physical games such as relay races. Those participating in the yoga arm of the study were found to have a significant decrease in breath rate, which seemed more regular, but no significant increase in skin resistance. Both groups showed a significant decrease in resting heart rate. These findings suggest that yoga practice may reduce levels of fear and anxiety more so than physical activity alone. This has implications for setting the background of emotional stability to execute physical demands of everyday activity.

Platania-Solazzo et al[35] conducted a study with similar implications, in which the effects of relaxation therapy were assessed in a population of 40 hospitalized children and adolescents who had a diagnosis of adjustment disorder and depression. This study assessed yoga's effect, along with massage and relaxation, on decreases in self-reported anxiety, anxious behavior, and fidgeting as well as increased positive affect. Decreases in cortisol levels were also noted, which have an indirect effect on the cardiorespiratory health of children.[36] PT traditionally incorporates several of the aspects mentioned in this intervention (massage, relaxation, and biofeedback), suggesting that yoga as a modality may provide unique and creative ways to attain goals in the cardiopulmonary practice pattern. Because this program incorporated massage, the specific effects of the yoga component are difficult to determine. However, we considered this evidence to be notable, especially since the elements of relaxation and biofeedback are intrinsic to the practice of yoga itself.

An additional study by Telles and Srinivas explored a population with normal cardiac function but increased levels of anxiety. This study analyzed the cardiopulmonary effects of yoga on volunteers who were visually impaired (VI).[37] This sample displayed similar baseline measurements to the socially or emotionally traumatized population of community home girls[32]: higher breath rates, heart rates, and diastolic blood pressure. Previous studies found that young people with VI have significantly higher levels of anxiety than their age-matched peers,[38] to which increases in heart rate is often attributed. In the Telles and Srinivas study, 24 children with VI, ages 12 to 17 years, were age matched with normal-sighted peers. Half of the pairs participated in yoga for an hour each day, while the other half of the pairs performed "physical activity" working in the garden and stretching. After 3 weeks, the rate of respiration was reduced in the children with VI who participated in yoga. There was no change in the children who participated in the physical activity group. These results show that although children with VI have higher physiologic arousal than children who are normal-sighted, this arousal may be reduced after participation in yoga. These studies point out yoga's utility in children with psychosocial impairments.

Four studies explored the effect of yoga on children with specific respiratory impairments, namely, asthma. However, only one of these studies[39] restricted participation to the pediatric population. In the study by Jain et al[39], 46 children, with a mean age of 15.8 years and a childhood history of asthma, were followed through 40 days of yoga

TABLE 3

Cardiopulmonary Evidence

No.	Study	1st/2nd Reviewer	Features	Participants	Intervention	Endpoints	Summary	Evidence Level
1	Clance et al[43]	RG/MLG	To evaluate the effects of a group process aimed at increasing the body satisfaction of children through the use of yoga exercises and awareness training.	12 African American 3rd year students enrolled in an elementary school in a large southern city. These subjects were selected from a pool of 17 students identified by their PE instructor as poorly coordinated and minimally involved in PE classes, receiving lowest scores on a subjective test measuring body satisfaction. Subjects were then randomly assigned to either a control (n = 6) or experimental group (n = 6).	Treatment sessions conducted 3×/week for 4 weeks in 30 min sessions. Experimental group received yoga exercises developed for children and awareness exercises, while the control group continued to attend regular PE classes.	Experimental group showed an increase in demonstrated body satisfaction as per Children's Body Satisfaction Test and Human Figure Drawing tests, whereas no such change was found in the control group.	Yoga appears to facilitate improvement in body satisfaction. Further, yoga may present a means of changing negative evaluations of the self and the body before these become deeply engrained in the self-concept of the child.	4
2	Jain et al[39]	RG/MLG	To examine the effects of yoga on resting pulmonary functions, exercise capacity, and exercise-induced bronchial lability index in young children with a history of childhood asthma.	46 young children with a history of childhood asthma (mean age = 15.8 yrs). All subjects had a clinical history and evidence of recurrent episodes of asthma during the last year. All participants had mild to moderate asthma and exercise-induced bronchoconstriction.	Subjects admitted for 40 days in the hospital of the Central Research Institute for Yoga. Daily yoga for 90 min in the morning and 1 hr in the evening was taught by a team of yoga instructors (yogic cleansing procedures, postures, and breathing).	Yoga training resulted in a significant increase in pulmonary function and exercise capacity. A follow-up study spanning 2 yrs showed a good response with reduced symptom score and drug requirements in these subjects.	It is concluded that yoga training is beneficial and may improve FVC, FEV, and MMFR. The findings show that yoga training decreased exercise induced bronchoconstriction.	2B
3	Khanam et al[42]	MLG/LQ	Examined whether autonomic and pulmonary functions are improved after a short-term yoga training.	Six males and three females with age ranges 12–60 yrs (with average duration of disease 13.55 yrs).	Yoga asanas, pranayama twice/day for 1 hr each session (14 sessions) for 7 days at a camp in New Delhi. Patients were kept under the same relaxed environmental conditions.	RHR significantly decreased; sympathetic reactivity reduced; Pulmonary function tests showed improvement.	Very small sample size, but initial suggestion that persons with asthma can benefit from a short-term yoga program.	3B
4	Nagendra and Nagarathna[41]	MLG/LQ	Prospective cohort followed 570 subjects with asthma for 3–54 mos and measured clinical cardiopulmonary parameters over time (parameters are extensive, ranging from no. of attacks per week to sputum production).	Age range 7–78 yrs; majority of participants were males; clinical study over a period of 3 yrs.	Yoga training for 2 weeks (2.5 hr daily) or 4 weeks (1.25 hr) included asanas, pranayama,meditation, devotional session and lecture.	Cohort was followed for 3–54 mos. Participants categorized into 1 of 3 groups: those who practiced irregularly, regularly, and those that discontinued; Subjective and objective data collected on 30 parameters (18 specific and 12 general).	Regular group practice showed most improvement while the irregular group the least; peak expiratory flow rate showed significant improvement toward normalcy; approximately 69% of the total group reduced or stopped medication; most of the specific parameters improved.	2B

(Continued)

TABLE 3
Continued

No.	Study	1st/2nd Reviewer	Features	Participants	Intervention	Endpoints	Summary	Evidence Level
5	Nagarathna and Nagendra[40]	MLG/LQ	Case controlled clinical trial to determine the benefits of yoga on asthma.	106 patients with established bronchial asthma. Fifty-three randomly allocated patients willingly served as controls, continuing taking their usual drugs during the study. Age range 9–47 yrs; 38 males and 15 females. 53 pairs matched for age and sex, type and severity of asthma.	Two week training in an integrated set of yoga exercises (breathing, meditation and devotional session) for 65 min daily.	Case-control groups were followed for up to 30 mos. All were evaluated at 6 mo intervals on numbers of attacks, severity score, drug treatment score and peak flow rate.	Drop-out rate high (25 subjects). However, there was a significantly greater improvement in the yoga group in the weekly number of asthma attacks, scores for drug treatment, and peak flow rate.	3B
6	Platania-Solazzo et al[35]	RG/MLG	The immediate effects of relaxation therapy were assessed in 40 hospitalized children and adolescents (ages 8–19, mean = 13.4 with 1/2 the sample being adolescent) with diagnoses of adjustment disorder and depression.	Relaxation therapy (RT) effects were assessed using a within subjects pretest/post test design and by comparison with a control group of 20 depressed and adjustment disorder patients who watched a 1 hr relaxing videotape. (40 in experimental group, 20 in control).	The 1 hr RT class consisted of yoga exercise, a brief massage, and progressive muscle relaxation. This class was offered two times a week.	Decreases were noted In both self-reported anxiety and in anxious behavior and fidgeting as well as increases in positive affect in the RT group, but not the video group. In addition, adjustment disorder pts and a 1/3 of depressed pts showed decreases in cortisol levels following RT, while no changes were noted in the video group.	Both diagnostic groups (adjustment disorder and depression) appeared to benefit from the RT class.	2B
7	Stueck and Gloeckner [5]	RG/MLG	Training of relaxation with elements of yoga for children technique (Stress handling program).	48 fifth grade-pupils who showed abnormal examination anxiety. 21 were placed in experimental group, and 27 into control group.	15 sessions of 60 min (relaxation, yoga, and group activity).	Pre/post comparison of psychologic and physiologic variables with three measuring intervals (rating scales of subjective feelings and electrodermal activity).	Training can increase emotional balance in the long-term and reduce fears. Feeling of helplessness was clearly reduced.	2B
8	Telles et al[32]	MLG/LQ	Determine differences in HR, breathing rate and skin resistance between a yoga program or a group that participated in games.	28 girls (aged 12–16 yrs) from community homes with a history of difficulty in adjusting at home or in society. 14 pairs were matched for age and duration of stay in the home and random assignment to either group (yoga or games).	Intervention lasted for 6 mos: 1 hr every day of yoga (postures for 50 min and relaxation for 10 min) or 1 hr games (40 min) and relay races (20 min).	Measurements taken: EKG and volumetric pressure transducer (for respiration and skin resistance).	Yoga and games decreases HR; yoga also significantly decreased breath rate; no significant change in skin resistance in either group. Results suggest that a yoga program which includes relaxation, awareness, and graded physical activity is a useful addition to the routine of children in the community home.	2B

(Continued)

TABLE 3
Continued

No.	Study	1st/2nd Reviewer	Features	Participants	Intervention	Endpoints	Summary	Evidence Level
9	Telles and Srinivas[37]	MLG/LQ	Ascertain differences between rates of breathing, HR and diastolic BP between children who are visually impaired and those who are normal sighted and the effects of yoga vs physical activity on these parameters.	28 children (aged 12–17 yrs) matched for age and degree of blindness randomized to yoga or physical activity.	Intervention lasted for 3 weeks: 1 hr every day of yoga (postures for 50 min and relaxation for 10 min) or 1 hr of physical activity (gardening and stretching).	Measurements taken: BP, EKG, volumetric pressure transducer (for respiration and skin resistance).	After 3 weeks, yoga group showed significant reduction in breath rate (no change in physical activity). Results suggest that children with visual impairment have higher physiological arousal than children with normal sight, with a marginal reduction in arousal following yoga.	2B
10	Udupa et al[31]	MLG/LQ	Determine whether pranayam training has an effect on ventricular performance, in effect improving cardio respiratory functions.	24 school children (healthy boys aged 13–15 yrs) randomly assigned to pranayam breathing or control for 3 mos.	Pranayam breathing or normal breathing, 20 min daily for a duration of 3 mos.	Systolic time intervals and cardiac autonomic function tests, both noninvasive tests for measuring ventricular performance.	Pranayam modulates ventricular performance by increasing parasympathetic activity and decreasing sympathetic activity.	2B

training. Increased capacity was found in the subjects' forced expiratory volume, distance walked in a 12-minute time period, and overall physical fitness as assessed by a modified Harvard Step Test. Although only 26 patients could be followed for up to 2 years, these patients showed continued reduction in symptoms, along with decreased drug requirements. Additionally, 14 of these patients (all initially diagnosed with mild asthma) who continued yoga practices everyday for 15 to 30 minutes remained asymptomatic, suggesting the utility of regular practice.

Three additional studies strengthen the evidence for yoga in the asthmatic population. However, these studies include, but are not necessarily restricted to the pediatric population. Two of these studies were conducted by Nagendra et al.[40,41] In 1985, a case controlled study by Nagendra et al[40] reported significant improvements in the weekly number of asthma attacks, scores for drug treatment, and peak flow rate in yoga participants versus nonparticipants. Subjects were matched for age, sex, type, severity and duration of asthma. The rigor of this study was weakened by a high dropout rate. In 1986, Nagendra et al[41] strengthened their findings with a prospective cohort study of 570 asthmatics, which explored the use of yoga over an extended time period (ranging from 3 months to 4.5 years). Results revealed regularity of practice to be the strongest predictor of improved peak expiratory flow and decreased use of medication. An additional study by Khanam et al[42] found a positive correlation between yoga and cardiopulmonary improvements. This study was underpowered with a markedly shorter time frame of intervention (7 days), suggesting that asthmatics can benefit from even a short-term yoga program.

Two additional studies suggest that yoga may improve cardiorespiratory parameters in children as a secondary effect of decreased anxiety. Clance et al[43] analyzed the effects of yoga on body satisfaction in a study involving 12 third grade students. Six students in the experimental group receiving yoga demonstrated improvements in self-image, while the six students in the control group did not. These results suggest that yoga may reduce stress and anxiety related to low body satisfaction or poor self-image in children. Further, the breathing techniques used in yoga foster decreased anxiety.[32] Although underpowered and considered pilot in nature, this study has important implications for the physical aspects of development that are indirectly impacted by psychosocial parameters.

Further, a study by Stueck et al[5] found that yoga and relaxation techniques may increase emotional balance in the long term, reduce fears and feelings of helplessness, as well as aggression and negative feelings, and improve overall well-being. This study used a stress-handling program with elements of yoga in 48 fifth grade students with examination anxiety. Postintervention, the participants transferred the learned breathing techniques and self-instructions to situations beyond school to promote healthy stress management and stress prevention, both of which are a means of primary prevention of cardiopulmonary complications.[44]

MUSCULOSKELETAL EFFECTS OF YOGA

We reviewed four studies pertaining to the musculoskeletal practice pattern. Two of the four studies were classified as 2B level of evidence, while the other two were assigned level 3B (Table 4). These studies reveal that yoga may be used with children developing typically, or children who are not meeting national norms for fitness and body composition, or children with elevated stress levels to improve musculoskeletal parameters.

Orthopedic injuries in children are often caused by lack of strength and flexibility,[45] which are addressed in the musculoskeletal practice pattern. The four studies reviewed showed significant effects of yoga and its breathing techniques on the musculoskeletal system in children. Three of these four studies were from the *Indian Journal of Physiology and Pharmacology*.[46–48] Although these studies were not very recent, they lay down the foundational work in this body of evidence, and provide a starting point upon which to build future studies. The results and conclusions of these studies suggest that yoga can be introduced during school to improve physiological function, overall health, and performance of students. Further RCTs are needed to determine definitive effects of yoga.

A study by Mandanmohan et al[46] found that 6 months of yoga training in 20 school children aged 12 to15 years produced significant gains in handgrip strength and endurance as well as inspiratory and expiratory muscle strength. This research design involved yoga training that took place over more than 6 months, which allowed the study to examine the long-term effects of yoga training. Perhaps future studies could involve a larger number of subjects, and examine the effects of yoga after the 6 months of training.

Similar gains in grip strength were found in a study by Raghuraj et al,[47] in which school children 11 to 18 years old took part in pranayama breathing for 10 days. Increased grip strength in both hands was found in the pranayama group, while no change was found in the control group. This study used random assignment to one of five groups that spanned a large range of children's ages (11–18 years old). An additional study by Raghuraj and Telles replicated these findings of increased grip strength after 6 months of yoga in 12- to 16-year-old girls.[48] These gains have implications for using yoga for total body strengthening.

Obesity, another growing concern in our pediatric population, may also be reduced through the implementation of yoga programs. A pilot study by Slawta et al[49] entitled "Be a Fit Kid" included a 12-week program of yoga designed to improve physical fitness and nutritional habits in children. The program also included a physical activity component (running, jumping, and strengthening) along with a nutrition program. After the intervention, significant improvements were found in body composition and fitness in those who participated 75% of the time. Because the "Be a Fit Kid" program used a holistic approach, the specific effects of the yoga component are difficult to determine. However, we felt that the study was important to include, given that it portrays yoga as an important contributor to an overall healthy lifestyle. Considering the recent trend of child participation in yoga classes, it is likely that more studies investigating children who are obese should be conducted with more rigorous methodology. This pilot study established the framework for replication in a larger, randomized sample.

Thus, in addressing the musculoskeletal issues of flexibility and strength, these studies demonstrate that yoga can have an impact on stress management and obesity. Both of these issues having a major impact on the socialization of developing children, so it can be seen that yoga not only impacts physically, but also emotionally and psychosocially. Therefore, PTs can consider yoga as a tool for not only musculoskeletal, neuromuscular, and cardiopulmonary problems, but also as a holistic approach to the entire mind–body of these children, thus addressing many issues that arise in children developing typically and atypically.

INTERPRETATION

This review summarizes available evidence regarding the effects of yoga as an intervention for QOL and physical outcomes in children. None of the reviewed studies provided adequate data to assess improvements in QOL over a significant part of childhood and adolescence, as most were of short duration. The 24 studies included in this review were of variable quality, and none were considered to be of high quality. Our conclusions are tempered by this fact. Clearly, further progress must be made to improve research quality and include measures of QOL. Future trials should focus on adequate randomization, concealment of allocation, and blinding of outcome assessors throughout the study.

A noteworthy feature of trials included in this review was the wide variability in study interventions. Many different types of yoga regimens were prescribed. The diversity in yoga prescription is not surprising, given the culture from which yoga emanates. Westernization of this modality may compromise the full intent of yoga practice in the United States when compared with India. Conversely, the wide variety in study outcomes and measurement methods is surprising. The short duration or complete lack of follow-up data examining the effect of yoga on QOL and rehabilitative outcomes in the long term are also noted. Moreover, data are lacking to support the use of yoga in preventing further disability in these three practice patterns.

A further limitation is the nonspecificity with respect to the timing of the yoga intervention. Clinical heterogeneity was evident, particularly, in trials carried out during treatment for asthma. This resulted from trials in which the participants were undergoing one of a variety of additional drug treatments; therefore, confounding issues are of concern.

Finally, poor adverse event reporting in most of the studies limits any conclusions about the relative safety of yoga as an exercise, and the small samples provide insufficient power to detect meaningful differences in rates of rare

TABLE 4
Musculoskeletal Evidence

No.	Study	1st/2nd Reviewer	Features	Participants	Intervention	Endpoints	Summary	Evidence Level
1	Mandanmohan et al[46]	LQ/RG/MLG	Effect of yoga training on respiratory pressures and handgrip endurance.	40 student volunteers, ages 12 to 15 yrs.	Yoga training (asanas and pranayamas) for 6 mos and control group.	Yoga training produced statistically significant ($p < 0.05$) increase in hand grip strength and hand grip endurance. Yoga training produced statistically significant ($p < 0.001$) increase in maximum expiratory pressure, maximum inspiratory pressure, forced expiratory volume, and peak expiratory flow rate.	Yoga training for 6 mos improves lung function, strength of inspiratory and expiratory muscles as well as skeletal muscle strength and endurance. It is suggested that yoga be introduced at school to improve physiological function, overall health, and performance of students.	3B
2	Raghuraj and Telles[48]	LQ/RG/MLG	Compare motor and sensory (visual) performance in three groups of subjects: girls in a community home who had learned yoga, girls in a community home trained in physical activity, and girls who were attending a regular school.	80 girls (ages 12–16 yrs) from a state-community home because of difficulty in adjusting at home, at school, or in society.	6 mos of yoga, 6 mos of physical training, or neither (control group).	Physical training group had significantly lower critical flicker fusion frequency, higher degree of optical illusion, and lower right hand grip strength than control group. Yoga group had higher critical flicker fusion frequency, lower degree of optical illusion, and marginally greater hand grip strength than the physical training group, but was not significantly different from the control group.	The reported higher stress levels in community home subjects reduced sensory perception by causing change at peripheral and central levels. To some extent, yoga modifies this effect. Additionally, yoga appeared to improve hand grip strength.	2B
3	Raghuraj et al[47]	LQ/RG	Determine whether breathing through a particular nostril has a lateralized effect on hand grip strength.	130 right hand dominant school children between 11 and 18 yrs of age.	Random assignment to 5 groups. Each group had a specific yoga practice in addition to the regular program at a 10 day yoga camp: right nostril breathing, left nostril breathing, alternate-nostril breathing, breath awareness, and practice of mudras.	The right-, left-, and alternate-nostril groups had a significant increase in grip strength of both hands without any lateralization effect. The breath awareness and mudra groups showed no change.	Yoga breathing through a particular nostril, or through alternate nostrils increases hand grip strength of both hands without lateralization.	2B
4	Slawta et al[49]	LQ/RG/MLG	"Be a Fit Kid" Program aimed at improving physical activity and nutritional habits in children.	75 children (ages 6–12 yrs).	12 week program (Be a Fit Kid) (3×/wk for 2 hr) of physical activity (running, jumping, yoga, and strength exercises) and nutrition (diet rich in vegetables, fruits, unsaturated fats, and whole grains, and low in saturated fat and sugar).	Significant improvements were observed in body composition, fitness, nutritional knowledge, dietary habits, and in those that participated 75% of the time, significant reductions in total cholesterol and triglyceride levels.	Health promotion programs can be well received by children and may favorably alter overweight and the development of adult lifestyle-related diseases.	3B

adverse events. For example, inverted postures can impact blood pressure[50,51] and represents a barrier to exercise for some patients, yet none of the included studies formally explained or monitored for the effect of specific postures.

The evidence suggests that yoga is an effective intervention to improve cardiorespiratory fitness, physical functioning, and behavior in children and adolescents. All the studies showed an effect and this may due to researcher or selection bias. Although these preliminary results are promising, the findings are based on a relatively small number of trials with significant methodological weaknesses. On the basis of our findings, we make the following research recommendations. Methodologically rigorous studies designed to examine different yoga regimens (see Table 1) are needed to better understand the role of yoga as it impacts the developing child and QOL. The yoga prescription should be reported in detail (frequency, intensity, time, and type of exercise) to allow for determination of exercise dose–response. To this end, adherence to exercise should be reported for both completion of exercise sessions (attendance) and yoga intervention (intensity and duration). Furthermore, monitoring of activity in the comparison group(s) is necessary to assess potential contamination. Consensus is required on standardized methods of assessing physical fitness and body composition to allow for pooling of data and for comparisons across studies. Future trials should formally monitor for, and report the incidence of, potential adverse events such as change in blood pressure.

SUMMARY OF LITERATURE REVIEW

Complementary and alternative medicine (CAM) encompasses five areas of modalities according to the National Institutes of Health—National Center for CAM: biologically based interventions, manipulative and body-based methods, mind–body therapies, energy-based approaches, and alternative medical systems. Yoga is one mind–body therapy that has emerged as an educational-based intervention and to improve various medical conditions for children.

Patient expectations regarding CAM interventions have important implications for treatment adherence, attrition, and clinical outcome.[52] Little is known, however, about parent and child treatment expectations regarding CAM approaches, especially yoga for problems presented by children and adolescents. One study revealed that parents often have higher expectations of CAM therapies than do their children.[52] Additionally, enhanced expectations often resulted in better outcomes. Thus, the use of alternative modalities must take into consideration these influential factors. Therefore, it is important that PTs are increasingly aware of the potential complementary and beneficial effects of various CAM modalities in children's rehabilitation.

The use of yoga for rehabilitation may have diverse applications. Yoga practice may benefit children with mental challenges by improving their mental ability, along with motor coordination and social skills. Children with physical disabilities may also experience restoration of some degree of functional ability after practicing yoga. Children who are VI can decrease their abnormal anxiety levels, and children in a group home can improve their sleep, appetite, and general well being, as well as a decrease in physiological arousal.[53]

Evidence from the previous studies of yoga as a CAM intervention have implications for PTs in the neuromuscular areas of learning, motor control, and coordination. PTs might apply these findings to their patients with asthma or simply as a form of biofeedback in stress management. Further, outcomes may be enhanced by applying findings from these studies to young athletes or children who are overweight. Regardless of the goal, yoga seems to be a multitasking modality that simultaneously treats physical impairments and psychosocial issues such as stress, anxiety, or hyperactivity. Many of these studies set out to measure purely physical parameters, but encompass psychosocial issues. Moreover, many of the studies in this review overlap or address multiple practice patterns, making it difficult to distinguish the effects of yoga on one specific impairment.

The available studies according to Sackett classification system[17] are predominantly level 2B grade evidence and below. It is well known that the inclusion of nonrandomized or uncontrolled trials leads to an overestimation of the effect of an intervention. Therefore, as noted in the studies presented in this article, yoga has a consistent trend in improvement. However, it is recommended that more RCTs be planned for future examination of the evidence for yoga to be consistently included into the PT plan of care. Specific measures of QOL should be added to physiologic data collection. In addition, future meta-analyses should be restricted to RCTs whenever possible.[54]

Much of the literature reviewed has been conducted in India and comprises all the elements of yoga including postures (asanas), breathing (pranayama), and spirituality (meditation). As Eastern philosophies and practices are taken to other countries, it may be compartmentalized without the lack holism of the philosophy and practice when examined in research. Therefore, appropriate use and full description of the practice of yoga is required for future design of clinical trials. Further research is needed to explore the integration of yoga into clinical practice. PTs treating children have an opportunity to add to existing exercise protocols and incorporate the benefits of yoga. However, research is needed to determine the best forms of yoga for children with specific impairments and to establish a dose–response relationship for children of different ages.

This review of the literature supports evidence for yoga that guide us in determining issues that will be important in the design of larger pediatric rehabilitation clinical trials. Future studies should examine the effect of yoga, as well as the magnitude and the variability of the response throughout childhood and adolescence. Compelling evidence exists that demonstrates the effect within the neuromuscular, cardiopulmonary, and musculoskeletal practice patterns. The breadth of these studies has implications in

all areas of PT practice, particularly in complementing existing wellness programs and clinical interventions for children.

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