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The effects of yoga practice on balance, strength, coordination and flexibility in healthy children aged 10–12 years



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ABSTRACT

Objective: The purpose of this study was to investigate the effects of yoga practice on balance, strength, coordination, and flexibility in healthy children aged 10–12 years.

Study design: Quasi-experimental, nonrandomized.

Background: Research on the effects of yoga in children has focused on the benefits seen in non-healthy children or on the effects on hand grip strength and motor performance. The studies on the effects of yoga on balance, strength, coordination, and flexibility have been limited.

Methods and Measures: A convenience sample of 26 children, aged 10–12 years was obtained. The children participated in 40 min yoga sessions, led by a registered yoga teacher, 1–3 times per week for 8 weeks. The Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2), the sit and reach test, and the 90/90 hamstring flexibility test were administered at baseline and at the end of the 8 weeks. Descriptive statistics were calculated for all measurements. A Shapiro-Wilk test was used to test normality. A Wilcoxin signed-rank test was used to analyze pre- and post-test measurements for all variables.

Results: There was a statistically significant within-subject difference from pre-test to post-test for balance ($p = 0.026$), sit and reach ($p = 0.000$), popliteal angle right ($p = 0.005$), and popliteal angle left ($p = 0.018$). There were no statistically significant differences in strength and bilateral coordination from pre- to post-test measurements.

Conclusions: Yoga may be a beneficial form of exercise in the school-based setting for improving balance and flexibility in healthy children.

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1. Introduction

Yoga is a practical philosophy that aims at uniting the body, mind and spirit for health and fulfillment. This tradition originated in India and has been practiced there for over two millenia (Mehta, 1998). Yoga includes a variety of body positions or postures maintained for a period of time that are performed gently and with a smooth progression from one posture to the next. Potential benefits of yoga practice include improvements in energy, muscle tone, fine motor coordination, flexibility, postural alignment, and cardiovascular fitness (Bera and Rajapurkar, 1993; Dash and Telles, 1999; Galantino et al., 2008; Konar et al., 2000; Telles et al., 1997; Telles and Srinivas, 1998). Other benefits reported following yoga

training are increased attention and concentration, improved behavior, and relaxation (Berger et al., 2009; Harrison et al., 2004; Jensen and Kenny, 2004; Kaley-Isley et al., 2010; Powell et al., 2008).

Research on the effects of yoga in children is emerging and several studies have been conducted with non-healthy children, such as those with asthma, behavioral disabilities and cancer (Cramer et al., 2014; Galantino et al., 2008; Harrison et al., 2004; Hooke et al., 2016; Jain et al., 1991; Ndetan et al., 2014; Peck et al., 2005; Tahan et al., 2014; Wurz et al., 2014). Many of the other studies examining the effectiveness of yoga practice with children and/or adolescents have focused primarily on handgrip strength and motor performance.

Dash and Telles found a significant improvement in handgrip strength in children aged 12–15 years who participated in only 10 days of yoga training (Dash and Telles, 2001). Thombe et al. studied 27 subjects and found a significant improvement in handgrip strength after 12 weeks of yoga (Thombe et al., 1992). In a study by

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Raghuraj et al., children ages 11–18 years participated in a 10 day yoga camp and bilateral grip strength improved (Raghuraj et al., 1997). Additionally, Mandanmohan et al. noted a significant improvement in handgrip strength and endurance in children ages 12–16 years following 6 months of yoga training when compared to age and gender-matched controls (Mandanmohan et al., 2003).

In regards to motor performance, Telles et al. found an increase in static motor performance after 10 days of yoga training in school children aged 9–13 years (Telles et al., 1993). Two groups of 45 children were assessed using a steadiness test at the beginning and the end of a 10 day period, during which time one group received training in yoga while the other group did not. During the 10 day period, the yoga group received training in special physical postures, voluntary regulation of breathing, maintenance of silence, as well as visual focusing exercises and games to improve attention span and memory. After 10 days, the yoga training group showed a significant 17% decrease in errors, whereas the control group showed no change. A later study by Telles et al. examined motor performance in young adults ages 17–22 years using the same model (Telles et al., 1994). The experimental group received 10 days of training in yoga and the control group continued their usual routine. The yoga practices lasted 8 h each day and included postures, regulated breathing, meditation and visual focusing exercises. Hand steadiness was studied for both groups at the beginning and end of the 10 day period, with a reported 18% decrease in the number of errors in static motor performance following yoga practice. This decrease in errors following yoga practice suggests that considerable neuroplasticity is still present in young adults, possibly leading to the improvements seen in motor performance. Additionally, other studies have suggested that as little as 10 days of yoga training can improve motor planning, execution, and reaction time (Dash and Telles, 1999; Manjunath and Telles, 2001).

Research has been limited in assessing balance, strength, coordination, and flexibility following yoga practice and many studies have focused on adults (Bukowski et al. 2006–2007, Galantino et al., 2004; Garfinkel et al., 1994; Krishnamurthy and Telles, 2007). Improving these areas in children has been shown to enhance sport performance, improve overall fitness and well-being, improve posture, and decrease risk of injury (Bundonis, 2007; Faigenbaum, 2000). Also, children with good flexibility and muscle strength, including core strength, have a more active lifestyle (Bundonis, 2007). One study evaluated the effect of yoga postures on balance, flexibility, and strength in healthy females aged 14–18 years (Donahoe-Fillmore et al., 2010). Yoga training occurred 2 times per week for 7 weeks and significant improvements were found only in hamstring flexibility measures after the intervention. Another study of children aged 9–11 years by Berger et al. examined the effects of yoga practiced for 1 h per week for 12 weeks (Berger et al., 2009). Balance improved significantly over the 12 weeks and flexibility also improved. With the lack of current research on yoga that focuses on healthy children, the purpose of this study was to investigate the effects of yoga practice on balance, strength, coordination, and flexibility in healthy children aged 10–12 years.

2. Methods and measurements

The institutional review board at the University of Dayton and the principal of a local elementary school approved this study.

Subjects: Study information and informed consent forms were sent home with all children in the 5th grade. Thirty-two forms were completed and returned. A total of 26 children (12 males and 14 females) ranging in age from 10 to 12 years completed the study. All children and their parents were assured that participation was voluntary and had no impact on grades or class standing. The children were divided into two groups based on class schedules and

led through yoga sessions by the same yoga teacher who had experience working with children and who had completed a 200-h teacher training program (RYT 200). Two children, one of each gender, were in a wrist cast throughout the study, and were instructed in modified yoga positions (such as forearm weight bearing instead of weight bearing on extended arms) when necessary. Due to the castings, these two children were unable to complete portions of the strength and coordination subtests of the BOT-2, but all other measurements were included in the analysis. Children who did not have parental approval to participate in yoga, who were unable to attend the yoga sessions 1–3 times per week and/or who were not present for either the pre- or post-measurements were not included in this study.

Procedure: Data were collected before and after 8 weeks of yoga practice. During data collection sessions, six physical therapy postgraduate students and one pediatric physical therapist administered the BOT-2 items and flexibility measurements. Small groups of 5–6 children were brought to the testing area and moved through 5 stations. Age and gender were recorded at one station. There were two identical stations for the balance, strength and bilateral coordination subtests, but children were required to only visit one station per subtest. Sit and reach and 90/90 hamstring flexibility measurements were taken at another station. All children completed each of the 5 testing stations before returning to their regular classrooms. For consistent measurement and scoring, each tester administered the same subtest at baseline and post-intervention, and scores were tallied and interpreted as outlined in the BOT-2 examiner's manual.

Measurement Tools: The Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2) contains 8 subtests to assess fine and gross motor skills in individuals ages 4–21 years. However, only subtests 4, 5 and 8 (bilateral coordination, balance and strength, respectively) were administered. The BOT-2 is a standardized assessment tool with a test-retest reliability of 0.80 for the total motor composite. The sit and reach test and the 90/90 hamstring flexibility test were used to measure flexibility. All items were administered while the child wore comfortable shoes and clothing.

Balance measurements: The balance subtest assesses postural control during static and dynamic movements, such as standing and walking with eyes open and eyes closed. This subtest contains 9 items including standing with feet apart on a line with eyes open; walking forward on a line; standing on 1 leg on a line with eyes open; standing with feet apart on a line with eyes closed; walking forward heel-to-toe on a line; standing on 1 leg on a line with eyes closed; standing on 1 leg on a balance beam with eyes open; standing heel-to-toe on a balance beam; standing on 1 leg on a balance beam with eyes closed. The balance items in this subtest, such as standing on a line with feet apart-eyes open and eyes closed; standing on 1 leg on a line-eyes open and eyes closed; standing on 1 leg on a balance beam-eyes open and eyes closed; and standing heel-to-toe on a balance beam, were scored by the number of seconds the child could hold the position, with the maximum score being 10 points for each. The walking items in this subtest, such as walking forward on a line and walking forward heel-to-toe on a line, were scored by the number of correct steps the child took, with the maximum score being 6 points for each. The scores for the 9 items were tallied to obtain an overall balance point score, with a maximum of 37 points possible. The interrater reliability for this subtest is 0.99 and the test-retest reliability is 0.45 for ages 8–12 years. The normative values for this age range are between 32 and 34 points (Bruininks and Bruininks, 2005).

Strength measurements: The strength subtest assesses upper and lower body strength, including trunk and core musculature. This subtest contains 5 items, including standing long jump

(measured in inches), knee push-ups and sit-ups (number completed in 30 s), wall sit and V-up (time held up to 60 s). Each item was given a numerical score with a higher number representing a better performance. The scores were totaled to obtain an overall strength point score, with a maximum of 42 points possible. The interrater reliability for this subtest is 0.99 and the test-retest reliability is 0.89 for ages 8–12 years. The normative values for this age range are between 23 and 26 points (Bruininks and Bruininks, 2005).

Bilateral Coordination measurements: The bilateral coordination subtest assesses gross and fine motor precision, integration, and manual dexterity through synchronization of the right and left sides of the body. This subtest contains 7 items that are scored based on the correct number of consecutive repetitions completed. The items include touching nose with index finger with eyes closed (maximum 4 touches); jumping jacks; jumping in place-same sides synchronized; jumping in place-opposite sides synchronized (maximum 5 jumps for each); pivoting thumbs and index fingers (itsy bitsy spider-maximum 5 pivots); tapping feet and fingers-same sides synchronized; and tapping feet and fingers-opposite sides synchronized (maximum 10 taps for each). The scores for the 7 items were totaled to obtain an overall bilateral coordination point score, with a maximum of 24 points possible. The interrater reliability for this subtest is 0.98 and the test-retest reliability is 0.65 for ages 8–12 years. The normative values for this age range are between 21 and 23 points (Bruininks and Bruininks, 2005).

Flexibility measurements: Flexibility was measured using the sit and reach test and the 90/90 hamstring flexibility test. The sit and reach test has an interrater reliability of 0.88–0.97 and a test-retest reliability of 0.63–0.99, while the 90/90 hamstring test has an interrater reliability of 0.96 (Gabbe, 2004; Nelson and Brandy, 2004). The sit and reach hamstring flexibility test began with the child seated on the floor with knees fully extended and ankles in neutral dorsiflexion against a box with attached ruler (Acuflex sit and reach tester, a standardized measurement tool). The 0 mark on the ruler started 13 cm proximal to the child's toes. The child was then instructed to place one hand on top of the other and slowly reach forward as far as possible while keeping the knees extended. The score was recorded as the final position of the fingertips on the ruler in centimeters. If a child was unable to reach the 0 mark on the ruler a negative number was recorded. The 90/90 hamstring flexibility test was performed with the child lying supine with the test leg flexed to 90° at the hip and the knee while the other leg was extended on the floor. The goniometer was centered over the lateral epicondyle of the femur and the arms of the goniometer were aligned with the lateral malleolus of the tibia and the greater trochanter of the femur. The thigh of the test leg remained still while the lower leg was passively moved toward terminal knee extension. The position was reached when the examiner felt a firm resistance to further motion and the knee angle measurement was taken (Nelson and Brandy, 2004).

Intervention: During the 8 week yoga practice, the same RYT 200 led every session. All sessions were held in the church basement of the school, except two that were held in the students' assigned classrooms. Both rooms provided adequate space for all necessary yoga positions. Throughout the 8 week period, each child

was scheduled to participate in 40 min yoga sessions, 1–3 times a week, for a total of 17 sessions. During weeks 1 and 5, yoga practice occurred only once per week due to student midterms and the Thanksgiving holiday. During weeks 2, 3, 4 and 8, yoga practice occurred twice per week due to the students' class schedule. During weeks 6 and 7, yoga practice occurred 3 times per week. Baseline data collection was held during the morning of the first day of week 1 and was followed by the first yoga session. Yoga sessions included a variety of individual and partner yoga postures, as well as breathing and meditation. Each session began with breathing and meditation, followed by individual poses focusing on flexibility, balance and strength, partner poses and ending with savasana. Specific postures varied with each session, as with most yoga classes, but every session followed this same format. As sessions progressed, more challenging poses were introduced and postures were held for longer periods. Yoga mats, blocks, straps and wall space were available at every session and the teacher provided verbal cues for adjustments or modifications and used props as needed. Post-measurements were taken after all yoga sessions were completed. Absences were recorded but were not adjusted for in the statistical analysis.

Statistical Methods: Data were analyzed using statistical software for the Social Sciences (SPSS, v.18.0, IBM, Somers, NY). Descriptive statistics were calculated for all measures. A Shapiro-Wilk test was used to test normality given the smaller sample size. A Wilcoxin signed-rank test was used to analyze pre- and post-measures for all variables. Significance was set a priori at $\alpha \leq 0.05$.

3. Results

A total of 12 males (average age 11.4 years) and 14 females (average age 10.3 years) completed the pre- and post-testing, as well as 8 weeks of yoga practice, and were included in the statistical analysis. Throughout this period, only 4 children were absent for a total of 8 yoga sessions, bringing the average number of attended sessions to 15.7. Data for 5 children were eliminated from statistical analysis because they were unable to attend the majority of yoga sessions due to conflicts with class schedules. Data for another student were eliminated because they were absent on the day of post-testing.

Means, standard deviations, and p-values were calculated for each outcome measure and can be found in Table 1. Results of the Shapiro-Wilk test indicated that the baseline coordination, strength, balance, and right popliteal angle measures were not normally distributed; therefore all measurements were analyzed with the Wilcoxin signed-rank test. Statistically significant within-subject changes were found for 4 of the 6 measures, which included balance ($p = 0.026$), sit and reach ($p = 0.000$), popliteal angle right ($p = 0.005$), and popliteal angle left ($p = 0.018$). No significant differences were seen in coordination and strength values between pre- and post-measurements.

4. Discussion

The overall results showed statistically significant improvements in balance and hamstring flexibility (sit and reach, right

Table 1
Means and standard deviations for pre and post intervention measurements.

	Balance (point score)	Strength (point score)	Coordination (point score)	Sit and Reach (cm)	Popliteal Angle R (degrees)	Popliteal Angle L (degrees)
Pre-intervention	32.92 (± 2.697)	24.46 (± 3.257)	23.28 (± 0.843)	8.231 (± 5.297)	50.15 (± 6.136)	48.69 (± 9.511)
Post-intervention	33.92 (± 2.529)	24.00 (± 3.765)	23.44 (± 0.821)	13.77 (± 7.782)	56.46 (± 9.296)	53.62 (± 10.226)
P Value	0.026*	0.455	0.356	0.000*	0.005*	0.018*

* indicates significance at a p-value of ≤ 0.05 .

popliteal angle, and left popliteal angle). No significant differences were found with coordination and strength.

Neuromuscular and musculoskeletal components including strength, balance, coordination, and flexibility are important influences on motor development at all ages. During pre-pubescent years, children are at their peak of motor planning and development and are constantly learning through trial and error. Evidence has shown that yoga can facilitate improvements in various physiological and psychological measures in both healthy and non-healthy children (Cramer et al., 2014; Dash and Telles, 1999; Hooke et al., 2016; Manjunath and Telles, 2001; Ndetan et al., 2014; Tahan et al., 2014; Wurz et al., 2014).

Statistically significant improvements in balance and hamstring flexibility may be attributed to the specific yoga postures utilized by the instructor. Many of the postures facilitated static balance, core stability and muscle stretching, with many focusing on hamstring flexibility. The results of the current study are consistent with the findings of Berger et al., (2009). This study found improvements in flexibility and significant changes in balance in children aged 9–11 years after a total of 12 h of yoga intervention (included meditation, breathing, and postures) over 12 weeks. Another study of healthy females aged 14–18 years also found that hamstring flexibility improved with 2 yoga sessions per week over 7 weeks (Donahoe-Fillmore et al., 2010).

In regards to coordination, most of the children achieved the maximum score possible on items in this subtest during pre-testing. This caused a ceiling effect, leaving little room for significant improvement following the yoga intervention. Minimal improvements were noted after the 8 week intervention period. In a previous study by Dash and Telles, subjects achieved a significant improvement in bilateral, repetitive, alternating finger tapping speed following 80 h of yoga intervention over a ten day period (Dash and Telles, 1999). Moreover, a subsequent study by Manjunath and Telles showed improved motor planning and sequencing in participants, suggesting that yoga practice can improve overall coordination and planning (Manjunath and Telles, 2001). In the current study, choosing a different outcome measurement to assess coordination may have better identified deficits and noted improvements.

Strength as measured by the BOT-2, did not improve over the 8 week yoga intervention. This lack of improvement may have occurred for several reasons. First, 8 weeks of intervention may not have been long enough to see a change in strength. Research has shown that children need 8–12 weeks of strength training to improve strength by 30–50% (Dehab and McCambridge, 2009; Faigenbaum et al 1996, 2003; Faigenbaum, 2000; Wescott, 2003). Training sessions should occur 2–3 times/week and include 2–3 exercises per major muscle group. Also, the child should perform 1–2 sets of 10–15 repetitions and resistance should be added gradually. The yoga postures practiced in each session were not completed at the frequency needed to meet these criteria for strength gains and yoga practice only occurred for 8 weeks. Also, the BOT-2 strength subtest contains items, including long jump, push-ups, sit-ups, prone trunk extension and wall sits that measure strength in a variety of muscle groups. Specific yoga postures for each session were not planned to target all of the muscles assessed in these subtest items and again were not completed with enough frequency to show gains in strength. In order to show gains in strength as measured by the items in the BOT-2, more intentional planning of poses would be needed to focus on specific body areas. Lastly, 14 of the 26 children were within the age appropriate range in this subtest at baseline, so significant improvements were not warranted. There is currently a lack of evidence indicating that a yoga intervention consisting of strengthening postures can lead to global changes in muscle strength. Previous studies using similar

yoga interventions have indicated improvements in hand-grip strength only (Dash and Telles, 2001; Mandanmohan et al., 2003; Raghuraj and Telles, 1997; Thombe et al., 1992).

There were several limitations with this study. The group of children was a convenience sample and a control cohort was not included. This makes it difficult to apply the results to all children aged 10–12 years. There was a drop-out rate of one child from the pre-to post-testing due to absence from school at post-testing. However, this absence did not appear to cause a considerable change in the results. Also, specific yoga poses were not documented for each session and were not selected to focus on specific body areas with enough frequency to attempt to see improvements in outcome measures, especially strength. The initial number of intended intervention days was not met with the duration of the study being limited to eight weeks, because of holidays, exams, and school functions.

Future studies should take into account the lessons learned from this study. Increasing the yoga sessions to 60 min at least twice per week for more than 8 weeks is recommended. Also, selecting different outcome measurements, especially to assess coordination, is needed to accurately assess deficits and reflect change. The teacher should keep a log of poses each session and select poses that target the specific outcomes they are working toward. Including a larger sample size and a control group is also recommended.

5. Conclusion

Previous studies have shown yoga practice to be beneficial for children 0–21 years of age. Yoga is currently being taught to children in studios across the country and is being used as an intervention by physical therapists to improve balance, flexibility and strength in children with impairments. This study supports the use of yoga in the school setting with healthy children and yoga may be a good alternative to sports to allow children to stay active and gain benefits in balance and flexibility. Further research is needed with healthy children to determine the benefits of yoga intervention on strength and coordination.

Conflicts of interest

The authors declare no conflict of interest.

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