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The Effectiveness of Simulated Developmental Horse-Riding Program in Children With Autism

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This study investigated the effectiveness of a 20-week Simulated Developmental Horse-Riding Program (SDHRP) by using an innovative exercise equipment (Joba®) on the motor proficiency and sensory integrative functions in 60 children with autism (age: 6 years, 5 months to 8 years, 9 months). In the first phase of 20 weeks, 30 children received the SDHRP in addition to their regular occupational therapy while another 30 children received regular occupational therapy only. The arrangement was reversed in the second phase of another 20 weeks. Children with autism in this study showed improved motor proficiency and sensory integrative functions after 20-week SDHRP ($p < .01$). In addition, the therapeutic effect appeared to be sustained for at least 24 weeks (6 months).

Pervasive developmental disabilities constitute a broad array of conditions that reflect a range of deficits, of which autism is the most-documented form (estimated prevalence 10–20 per 10,000 children; Newschaffer et al., 2007). Besides significant impairment in social interactions and communication, children with autism consistently have difficulties with sensory integrative and motor functions that may hamper their ability to participate in school and community activities (Ayres & Tickle, 1980; Smith, 2004).

Ayres (1979) describes two types of sensory integrative dysfunctions in children with autistic behaviors. One type is disturbances of sensory modulation that result in an inability to deal with the registration of or orientation to sensory input. It appears that some children fail to detect, manage, or perceive sensory information that leads to overresponding (sensory-avoiding behaviors), underresponding (sensory-seeking behaviors), or fluctuating between these responsive behaviors. Another type of dysfunction relates to sensory discrimination and perception that involve refined organization and interpretation of sensory stimuli (Case-Smith,

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1991). Motor planning, emotional-behavioral development, and visual-perceptual functions are likely to be affected by sensory discrimination and perception problems (Ayres, Mailloux, & Wendler, 1987; Mulligan, 1998). With respect to motor deficits, children with autism frequently experience unusual body postures and movements, atypical acquisition of motor milestones (Teitelbaum, Teitelbaum, Nye, Fryman, & Maurer, 1998), poor motor proficiency (Smith, 2004), poor postural stability (Koomar & Bundy, 2002), and lack of anticipatory movements and normal body concept (Reeves & Cermak, 2002).

Traditionally, the therapeutic activities for children with disabilities are carried out in a therapy room such as therapeutic exercises and sensory integration intervention using suspension equipment. It may become boring for both children and therapists after a period of time (Cherng, Liao, Leung, & Hwang, 2004), and certain therapeutic equipment is no longer appropriate for older or bigger children. To overcome these limitations, several alternative therapeutic options have been proposed, including aquatic activities and therapeutic horseback riding (THR). One of the purported benefits of the THR is provision of two levels of sensorimotor experiences. The lower level (passive interaction) offers various motor challenges by changing the movements of horses such that children can learn to control their body and postures in different positions (upright, prone, supine, forward, backward, and side-bending) on the horse's back. In addition, this level of sensorimotor experiences assists children in acquiring basic motor control skills and inhibiting unnecessary movements (Schmidt & Lee, 2005). The higher level (active interaction) presents various combinations of riding movements in which children can play and interact with others while on the horseback. The aim of this level is to facilitate active movements and create further opportunities to develop advanced motor skills as well.

Apart from these, the THR allows children to develop weight shift and postural control through constant practice, since a horse could walk over 6000–7000 steps in a 60-min therapy session (Spink, 1993). Along the same line, integration of kinesthetic, proprioceptive, and vestibular inputs can be promoted through the THR, which is critical to develop adaptive responses (Ayres, 1979; Biery & Kauffman, 1989).

Despite the above-mentioned therapeutic advantages of the THR, its benefits to children with autism remain elusive. Recently, innovative exercise equipment (Joba®; Kubota et al., 2006) was developed as an attempt to simulate the movements during real horse riding, thereby avoiding the expense and inconvenience of the THR. An additional feature of Joba® is that the adjustable pedal fits a wide range of children sizes. In light of the accumulating evidence for a role of the THR in motor functioning in children with cerebral palsy (CP; Haehl, Giuliani, & Lewis, 1999; MacKinnon, Noh, MacPhail, Allan, & Laliberte, 1995), we hypothesized that the THR is beneficial in remediation of sensorimotor deficits in children with autism. Therefore, the purposes of this study were twofold: (a) to design a Simulated Developmental Horse-Riding Program (SDHRP) using Joba® and (b) to examine the effectiveness of the SDHRP in improving motor and sensory integrative functions of children with autism.

Method

Participants

This study was conducted during 2007–08 in the pediatric therapy unit at a university-affiliated medical center, after approval by its ethics committee. Inclusion criteria for participants in this study were (a) a diagnosis of autism, (b) age from 6 to 10 years, (c) able to follow instructions, (d) parental commitment to allow participation, and (e) receiving regular occupational therapy. Children with autism were excluded from participating if any of the following conditions applied: (a) uncontrolled seizure, (b) severe self-injurious behavior, (c) congenital hip dislocation, and (d) severe sensory impairments.

Children were identified from relevant educational and clinical sources. Five elementary schools and three special schools located in a metropolitan city participated as educational sources in the current study. Clinical sources included the departments of rehabilitation medicine and pediatrics. We contacted the teachers and therapists at each participating school and hospitals, explained the goals and procedures of the study, and asked them to nominate children eligible for the study.

Eighty-six children meeting the study criteria were selected through these sources. An attempt was made to contact their parents or primary caregivers to explain the project and request consent. Of these, 15 refused and 71 agreed to participate in the study. All of these children received regular occupational therapy services, and none of them had any experience in horse riding. Before intervention, they were split into group A (35 subjects) and group B (36 subjects). Eleven children (5 from group A and 6 from group B) had dropped out because of conflicting schedules or sickness. Therefore, 60 children completed the whole 44-week SDHRP (20 weeks SDHRP, 20 weeks control, 4 weeks for assessment and transition).

In the final sample, 21.6% (n = 13) were girls (mean age = 91.11 years, SD = 3.76), and 78.4% (n = 47) were boys (mean age = 90.93 years, SD = 4.11). In general, the proportional distribution of gender in our sample roughly approximated those of previous literature. That is, autism occurs more frequently in boys than in girls, with a male-to-female ratio of 4.3:1 (Fombonne, 2005). The mean age of the fathers and mothers were 41.2 (SD = 6.2) and 37.7 (SD = 7.1) years, respectively. Educational levels of the mothers and fathers, respectively, were graduate school (n = 8 and 8), university or college (n = 24 and 34), senior high school (n = 22 and 16), and junior high school (n = 6 and 2). The occupations of the mothers and fathers, respectively, were categorized into four major groups: professional or central administration (n = 15 and 17), semiprofessional workers (n = 22 and 23), technical workers (n = 13 and 11), and semitechnical or nontechnical workers (n = 10 and 9; Wang et al., 1998).

Measures

Bruininks-Oseretsky Test of Motor Proficiency (BOTMP). The BOTMP (Bruininks, 1978) is designed to assess qualitative aspects of motor function that focus on acquisition of pattern of movement in children ranging in age from 4.5 to 14.5 years of age (Kroes et al., 2004). The test consists of a total score as well as separate measures of gross and fine motor skills. Gross motor (GM) composite is derived from performance on four subtests covering running speed and agility, balance, bilateral coordination, and strength, while fine motor (FM) composite summarizes performance on three subtests involving response speed, visual-motor control, and upper-limb speed and dexterity. A total composite can be obtained by summing the scores for the two composites and the upper limb coordination subtest. The higher the BOTMP composite scores, the better the motor outcome. The average age-adjusted standard scores for subtests and three composites are 15 (*SD* = 5) and 50 (*SD* = 10), respectively. Internal consistency reliability for the BOTMP subtests ranged from 0.38 to 0.92 (Bruininks, 1978). The estimates of interrater reliability ranged between 0.63 and 0.97, with a test-retest reliability of 0.80 to 0.94. The BOTMP showed moderate correlations with other motor performance tests (Croce, Horvat, & McCarthy, 2001).

Test of Sensory Integration Function (TSIF). The TSIF (Lin, 2004) is designed to identify sensory integrative dysfunction in children aged from 3 to 12 years. Sensory integration refers to the neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment (Ayres, 1972). When the sensory inputs from visual, auditory, vestibular, proprioceptive, and tactile systems are not integrated or organized appropriately in the brain, varying degrees of problems in development, information processing, and behavior may occur. The test consists of 98 items divided into 7 subtests: postural-ocular movement, bilateral integration, sensory discrimination, sensory modulation, sensory searching, attention and activity, and emotion and behavior. These subtests are made up of interactive activities that engage multiple sensory systems, including vestibular, proprioceptive, and tactile systems. Each item is rated on a 5-point Likert scale from 1 (*never*) to 5 (*always*), based on the frequency of targeted behavior during the entire observation period. Higher scores suggest poorer performance on sensory integration tasks. Subtest standard scores of the TSIF are based on a distribution having a mean of 50 and standard deviation of 10. Internal consistency for the overall test demonstrated a Cronbach's alpha of 0.89, while test-retest reliabilities for the TSIF subtest scores ranged between 0.82 and 0.94. The TSIF subtest scores varied significantly as a function of age, sex, and residential location (urban versus rural; Lin, 2004).

Procedure

The SDHRP was developed based on the Developmental Riding Therapy (Spink, 1993) and previous researches (Benjamin, 1997; Cherng et al., 2004; DePauw, 1986), with more emphasis on utilizing the principles of sensory integration, motor learning, and perceptual-motor training. A treatment plan was especially designed for each child that incorporated SDHRP activities compatible with the child's interest and current motor function. The SDHRP activities followed a development sequence of sensorimotor functions: (a) monolimb control; (b) unilateral control; (c) bilateral control; (d) contralateral control; (e) reach, grasp, and release; (f) finger manipulation; (g) sensory screening; (h) body image and discrimination of body parts; (i) static and dynamic balance; (j) motor planning; (k) laterality; (l) directionality; (m) bilateral integration; (n) oculo-motor control and visual tracking; (o) visual perception and visual-spatial relations; (p) position in space or change in position; (q) crossing the midline; (r) auditory discrimination; (s) tactile perception; (t) imitation of movement; (u) moving objects in space (catching and throwing skills); and (v) environmental competency.

The SDHRP was comprised of three sessions, with each session preceded by a warm-up. The first session involved simple limb movements and mat exercises, with the aim of increasing the child's body flexibility and motivation in learning. During the second session (mounted exercise), the child was instructed to ride on Joba® in different positions (sitting, prone, lying) to experience various horseback movements.

Its purpose was to enhance the child's body awareness, sensitivity, and coordination by means of vestibular, proprioceptive, and kinesthetic inputs. At the third session, the therapist offered a game that the child can play on the Joba® for the purposes of strengthening sensory integrative, cognitive, and affective skills and developing interpersonal relations and self-directed behaviors through interactive play.

Before the start of the study, a workshop was held to introduce the SDHRP to the participants and therapists. The SDHRP was conducted for one hour per session, 2 sessions per week, for a total of 40 sessions for each group. Both groups were assessed using the BOTMP and the TSIF during the first week (T1, the 1st week). In the first phase of 20 weeks (the 2nd to the 21th week), group A participants received the SDHRP in addition to their regular occupational therapy (OT) program while group B participants received regular OT only. And this was then interrupted for two weeks (T2, the 22th to the 23th week) for second assessment on both BOTMP and TSIF and group transition. In the second phase of 20 weeks (the 24th to the 43th week), the arrangements were reversed. Both groups were reassessed on both BOTMP and TSIF in the final week (T3, the 44th week). The regular OT included training in fine motor function, sensory integrative function, and activities of daily living.

Two certified OTs, each with more than ten years of clinical experience in pediatric rehabilitation participated in the intervention stage of the study. To ensure consistency in the treatment techniques delivered to the children within each group, the therapists were required to thoroughly review the training manual before the commencement of the intervention, in which a comprehensive listing of the SDHRP and regular OT activities were described in detail. Treatment fidelity was verified by an audit of 30 videotaped therapy sessions from both therapists at about first week and 3 months of intervention, 15 for each time period and for each group. Two pediatric OTs not involved in the current study separately rated the level of therapist's adherence to specific treatment approach in accordance with the recommended activities listed in the training manual, using a 4-point scale: 1 = *non/irregular* (0–24%), 2 = *rather irregular* (25–49%), 3 = *rather regular* (50–74%), and 4 = *regular* (75–100%). The median scores for the adherence of SDHRP and regular OT activities were 4.0 across raters and time periods.

Another two pediatric OTs, who were blind to child group status, administered the BOTMP and TSIF to the children at three assessments according to standardized procedures provided by the appropriate test manuals. The examiners undertook an intensive one-day training session led by the principal investigator. During training, particular attention was drawn to the tests' explicit nature, administration, and scoring. To meet the competency requirement in test administration, each examiner completed a case under the supervision of the principal investigator to ensure correctness and appropriateness in administering and scoring before formal testing. After training, a video recording of the assessment of one child was made. Each of the two therapists viewed the recording and scored it individually. High interrater reliability with the two instruments was reached, with 0.94 and 0.97 for the BOTMP and the TSIF, respectively. To decrease possible experimenter bias, the examiner did not reacquaint herself with the child's scores from the first assessment when conducting the second and the third assessments. Children were tested at an OT unit. The testing was conducted on an individual basis in one session lasting approximately an hour, with a suitable number of breaks to minimize the effects of fatigue.

Data Analysis

SPSS 15.0 for windows was used for data analysis. The chi-square test and the *t* test were employed to determine if differences exist between two groups in terms of gender and age. To compare the mean levels of performance on the BOTMP and TSIF between groups, multivariate analysis of variance (MANOVA) was applied. Partial η^2 (eta squared) was presented as an index of effect size. According to Portney and Watkins (2009), an effect size is "small" if $\eta^2 = 0.01$, "moderate" if $\eta^2 = 0.06$, or "large" if $\eta^2 = 0.14$.

Next, Cohen *d* was computed to quantify the magnitude of the difference among assessments for each group. In brief, for group A, differences in the BOTMP and TSIF scores between T1 and T2 and between T2 and T3 indicated effectiveness between SDHRP and regular OT and carry-over effects of the SDHRP, respectively. As for group B, differences in the BOTMP and TSIF scores between T1 and T2, and between T2 and T3, suggested possible effects of maturation and regular OT and effectiveness of the SDHRP, respectively. As a guide to interpreting these values, Cohen (1977) labeled an effect size "small" if ES ≥ 0.2 < .5, "moderate" if ES ≥ 0.5 < .8, or "large" if ES ≥ 0.8. Finally, effect sizes were again calculated by dividing the mean change in scores by the *SD* of baseline scores to quantify the magnitude of change from pre- to postintervention on the BOTMP and TSIF scores for each group.

Results

Group Comparability

The age, group A: $M = 93.6$ years, $SD = 11.2$; group B: $M = 83.8$ years, $SD = 7.1$, $t\,(58) = 0.84$, $p = 0.15$, and gender distribution, group A: female/male = 7/23, group B: female/male = 6/24, $\chi^2(1, N = 60) = 0.57$, $p = 0.40$, were similar between groups. Analysis of variance revealed no significant main effects of gender or of the interaction between gender and group (*p*'s > 0.05). To examine the difference between group A and B at three measurements, the MANOVAs were conducted with the standard scores of the BOTMP 8 subtests and TSIF 7 subtests as dependent variables. Results of MANOVA tests revealed no difference between group A and group B on both BOTMP, Wilks' $\Lambda = 0.92$, $F(7, 52) = 0.66$, $p = 0.71$, partial $\eta^2 = 0.08$ and TSIF, Wilks' $\Lambda = 0.96$, $F(8, 51) = 0.31$, $p = 0.95$, partial $\eta^2 = 0.90$, at first assessment (T1); it indicated homogeneity between groups before the intervention (Table 1). Significant overall differences were found on both BOTMP, T2: Wilks' $\Lambda = 0.09$, $F(7, 52) = 366.43$, $p < .0001$, partial $\eta^2 = 0.90$; T3: Wilks' $\Lambda = 0.51$, $F(7, 52) = 105.90$, $p < .0001$, partial $\eta^2 = 0.68$ and TSIF, T2: Wilks' $\Lambda = 0.01$, $F(8, 51) = 522.06$, $p < .0001$, partial $\eta^2 = 0.99$; T3: Wilks' $\Lambda = 0.03$, $F(8, 51) = 277.64$, $p < .0001$, partial $\eta^2 = 0.97$, between groups at the second (T2) and the third (T3) assessments. Follow-up univariate *F* test were performed accordingly. In light of the number of univariate analyses conducted, the Bonferroni α level was set at 0.006 (.05/8) and 0.007 (.05/7) for BOTMP and TSIF, respectively, for all follow-up analysis to maintain a family-wise error rate of < 0.05. As shown in Table 2 and Table 3, two groups performed significantly differently across test measures and the effect sizes were all large (> 0.14)

Table 1 Summary of the Univariate ANOVAs on the First Measurement (T1) for Each Group

Measures	Group Mean *(SD)* Test Scores: Group A (n = 30)	Group B (n = 30)	*F*	Partialη^2
BOTMP				
Running speed and agility	9.50 (1.11)	9.67 (1.12)	0.34	0.01
Balance	9.43 (1.04)	9.40 (1.04)	0.02	0.00
Bilateral coordination	9.40 (1.13)	9.60 (1.19)	0.44	0.01
Strength	9.53 (1.04)	9.37 (0.89)	0.44	0.01
Upper-limb coordination	9.90 (0.88)	10.13 (0.73)	1.24	0.02
Response speed	8.07 (0.87)	8.23 (0.73)	0.65	0.01
Visual-motor control	7.10 (0.88)	6.90 (0.76)	0.88	0.02
Upper-limb speed and dexterity	6.93 (0.87)	6.83 (0.65)	0.26	0.00
TSIF				
Postural-ocular movement	53.49 (2.55)	53.66 (2.47)	0.07	0.00
Bilateral integration	52.22 (0.81)	52.10 (0.82)	0.30	0.01
Sensory discrimination	65.59 (1.32)	65.72 (1.51)	0.12	0.00
Sensory modulation	63.74 (1.12)	64.06 (1.20)	1.20	0.02
Sensory searching	56.61 (0.53)	56.57 (0.57)	0.01	0.00
Attention and activity	58.81 (1.03)	58.82 (0.98)	0.07	0.00
Emotion and behavior	59.70 (1.70)	59.81 (1.75)	0.08	0.00

Note. ANOVA, Analysis of variance; Partialη^2, partial eta squared; BOTMP, Bruininks-Oseretsky Test of Motor Proficiency; TSIF, Test of Sensory Integration Function.

$p > 0.01$

Intervention Differences Among Three Measurements Within Groups

Estimates of effect size on BOTMP and TSIF for these two groups at three assessments are summarized in Table 4 and Table 5. Group A had significant improvements on all subtests of BOTMP at T2. Cohen *d* values for these comparisons between T1 and T2 noticeably exceed 0.8, thereby reflecting robust effect sizes. At T3, small effect sizes for all gross motor subtests and gross motor composite; medium effect sizes for subtests upper-limb coordination, response speed; and large effects sizes were found for upper-limb speed and dexterity and visual-motor control subtests, fine motor composite, and total motor composite. For group B, large effects sizes existed in all subtests except subtests strength and running speed and agility at T2, and large effects sizes were found in all subtests at T3.

Group A demonstrated significant improvements on all subtest of the TSIF at T2 with the smallest gain in postural-ocular movement subtest. Large effect sizes were found for all subtests at T3. For group B, large effects sizes were noted for all

Table 2 Summary of the Univariate ANOVAs on the Second Measurement (T2) for Each Group

Measures	Mean (SD) Group A (n = 30)	Mean (SD) Group B (n = 30)	F	Partialη^2
BOTMP				
Running speed and agility	14.50 (1.11)	10.43 (0.68)	294.43**	0.84
Balance	14.47 (1.07)	10.97 (1.03)	165.40**	0.74
Bilateral coordination	16.37 (1.10)	11.33 (0.92)	369.61**	0.86
Strength	14.33 (0.80)	9.77 (0.97)	394.11**	0.87
Upper-limb coordination	14.90 (0.88)	11.00 (0.91)	283.36**	0.83
Response speed	12.67 (0.48)	9.37 (0.49)	694.94**	0.92
Visual-motor control	13.80 (0.48)	8.90 (0.71)	971.57**	0.94
Upper-limb speed and dexterity	12.80 (0.41)	8.87 (0.63)	827.45**	0.93
TSIF				
Postural-ocular movement	40.54 (2.80)	51.44 (0.80)	420.92**	0.88
Bilateral integration	41.09 (1.70)	49.80 (1.62)	413.08**	0.87
Sensory discrimination	50.75 (2.49)	62.23 (1.73)	430.07**	0.88
Sensory modulation	47.32 (3.53)	61.35 (1.31)	416.99**	0.88
Sensory searching	50.75 (2.49)	55.44 (0.84)	291.00**	0.83
Attention and activity	44.63 (3.60)	56.34 (1.08)	287.86**	0.83
Emotion and behavior	42.57 (2.45)	54.80 (3.90)	95.27**	0.62

Note. ANOVA, Analysis of variance; Partialη^2, partial eta squared; BOTMP, Bruininks-Oseretsky Test of Motor Proficiency, TSIF, Test of Sensory Integration Function.
** $p < .01$

subtests with the smallest gain in postural-ocular movement subtest at T2. Large effects sizes were found in all subtests at T3, particularly in subtests postural-ocular movement, sensory modulation, and attention and activity.

Discussion

Implications for Intervention

Although empirical evidence supporting the benefits of therapeutic horseback riding in children with disabilities is abundant (Biery & Kauffman, 1989; Spink, 1993), studies regarding the effectiveness of simulated horseback riding are scarce. The results of this study testify to the positive impact of the SDHRP on motor proficiency and sensory integrative functions in children with autism.

Considering the small effect sizes for all BOTMP gross motor subtests in group A between T2 and T3 measurements (post-SDHRP phase), treatment gains of the SDHRP on gross motor function could be maintained for at least 23–24 weeks. In contrast, the sustained effect was not seen in fine motor function in view of the large

Table 3 Summary of the Univariate ANOVAs on the Third Measurement (T3) for Each Group

Measures	Mean (*SD*) Group A (*n* = 30)	Mean (*SD*) Group B (*n* = 30)	*F*	Partialη^2
BOTMP				
Running speed and agility	14.30 (0.84)	15.87 (0.86)	51.13**	0.47
Balance	14.27 (0.83)	16.40 (1.04)	77.54**	0.57
Bilateral coordination	15.91 (1.00)	17.00 (1.14)	18.75**	0.24
Strength	13.95 (0.41)	14.23 (0.57)	65.57**	0.53
Upper-limb coordination	14.30 (0.53)	17.07 (0.78)	254.50**	0.81
Response speed	12.43 (0.50)	13.37 (0.61)	41.34**	0.42
Visual-motor control	13.37 (0.51)	15.90 (0.76)	213.16**	0.78
Upper-limb speed and dexterity	12.33 (0.48)	13.17 (0.38)	55.77**	0.49
TSIF				
Postural-ocular movement	46.14 (2.02)	39.12 (2.23)	162.88**	0.74
Bilateral integration	47.34 (1.61)	39.26 (2.26)	253.95**	0.81
Sensory discrimination	56.85 (1.42)	47.93 (2.43)	298.91**	0.84
Sensory modulation	55.27 (2.96)	46.92 (3.10)	113.85**	0.66
Sensory searching	51.81 (1.39)	47.12 (3.40)	155.59**	0.73
Attention and activity	51.05 (1.10)	43.93 (2.93)	415.94**	0.88
Emotion and behavior	47.46 (1.58)	39.87 (1.29)	62.14**	0.52

Note. ANOVA, Analysis of variance; Partialη^2, partial eta squared; BOTMP, Bruininks-Oseretsky Test of Motor Proficiency, TSIF, Test of Sensory Integration Function.

** $p < .01$

effect sizes for all BOTMP fine motor subtests; however, the SDHRP did somewhat improve certain aspects of fine motor functions given that performance differences in visual motor control, upper limb speed and dexterity, and upper-limb coordination subtests were significant between T1 and T2 measurements in group A participants.

Significant improvement in gross motor function may be accounted for by the accumulated effects from a series of training steps that are goal-directed, structured, progressive, and interrelated. For instance, once the child learned to maintain equilibrium on Joba®, more challenging dynamic tasks such as rotating the trunks and tossing/catching balls on Joba® were introduced. After mastering these tasks, the child was better able to use body feedback to understand the outcome of movements (feedback), anticipate upcoming events (feedforward), and plan alternative strategies (Brooks, 1986). Concomitantly, the child was encouraged to rely more on internal feedback and self-evaluation of performance than external feedback from others. By adjusting the speed and angle of Joba®, more mature patterns of trunk control emerged from better use of feedback and feedforward mechanisms like riding on a real horse (Wheeler, 1997). Likewise, weight shifting could be enhanced by alternating the rhythm and direction of Joba®. The ability to control

Table 4 Summary of Effect Sizes on BOTMP for Group A and B

	T1-T2				T2-T3			
	Group A		Group B		Group A		Group B	
BOTMP	Change	ES	Change	ES	Change	ES	Change	ES
Running speed and agility	5.00	4.50*	0.76	0.68†	–0.20	–0.18‡	5.44	8.00*
Balance	5.04	4.85*	1.53	1.47*	–0.20	–0.19‡	5.43	5.27*
Bilateral coordination	6.97	6.17*	1.73	1.45*	–0.46	–0.42‡	5.67	6.16*
Strength	4.80	4.62*	0.40	0.45‡	–0.38	–0.48‡	4.46	4.60*
Gross motor composite	21.80	7.27*	4.47	1.61*	–1.35	–0.48‡	21.00	7.87*
Upper-limb coordination	5.00	5.68*	0.87	1.19*	–0.60	–0.68†	6.07	6.67*
Response speed	4.60	5.29*	1.14	1.56*	–0.24	–0.50†	4.00	8.16*
Visual-motor control	6.70	7.61*	2.00	2.63*	–0.43	–0.89*	7.00	9.86*
Upper-limb speed and dexterity	5.87	6.75*	2.04	3.14*	–0.47	–1.15*	4.30	6.83*
Fine motor composite	17.17	10.16*	6.76	5.08*	–1.04	–1.14*	13.70	4.89*
Total composite	43.96	10.85*	10.67	2.99*	–2.98	–0.92*	42.20	13.31*

Note. ES = effect size. To quantify the magnitude of the difference between tests, effect sizes (Cohen *d*) were calculated by dividing the mean change in a test score by the standard deviation of the test score at baseline to quantify the magnitude of change between two tests.

Positive values indicated improvements in motor proficiency.

*A Cohen *d* value ≥ 0.8 indicates a large effect size.

† A Cohen *d* value ≥ 0.5 < .8 indicates a medium effect size.

‡ A Cohen *d* value ≥ 0.2 < .5 indicates a small effect size.

Table 5 Summary of Effect Sizes on TSIF for Group A and B

	T1-T2				T2-T3			
	Group A		Group B		Group A		Group B	
TSIF	Change	ES	Change	ES	Change	ES	Change	ES
Postural-ocular movement	–12.95	–5.08*	–2.22	–0.90*	5.60	2.00*	–12.32	–15.40*
Bilateral integration	–11.13	–13.74*	–2.30	–2.80*	6.25	3.68*	–10.54	–6.51*
Sensory discrimination	–14.84	–11.24*	–3.49	–2.31*	6.10	2.45*	–14.30	–8.27*
Sensory modulation	–16.42	–14.67*	–2.71	–2.26*	7.95	2.25*	–14.43	–11.02*
Sensory searching	–5.86	–11.06*	–1.13	–1.98*	2.07	0.83*	–-8.32	–9.90*
Attention and activity	–14.18	–13.77*	–2.48	–2.51*	6.42	1.78*	–12.41	–11.49*
Emotion and behavior	–17.13	–10.08*	–5.01	–2.86*	4.89	1.99*	–14.93	–3.83*

Note. ES = effect size. To quantify the magnitude of the difference between tests, effect sizes (Cohen *d*) were calculated by dividing the mean change in a test score by the standard deviation of the test score at baseline to quantify the magnitude of change between two tests. Negative values indicated improvements in sensory integrative functions.

*A Cohen *d* value ≥ 0.8 indicates a large effect size.

† A Cohen *d* value ≥ 0.5 < .8 indicates a medium effect size.

‡ A Cohen *d* value ≥ 0.2 < .5 indicates a small effect size.

the trunk and shift body weight resulted in the improved walking and running abilities (Cherng et al., 2004; Patla, 1993).

Proactive visual and somatosensory control is an essential component of upper extremity movements (Augurelle, Smith, Lejeune, & Thonnard, 2003; Jeannerod, 1986, 1990), which is responsible for the correct execution of limb movement and the coordination between limbs and vision (Johansson, 1996; Whitney & Wrisley, 2004). During SDHRP training, the child must grab the handle of Joba® and modify posture and speed of upper extremities in response to trunk movements from time to time, with contributions of vision for perception processes in action. At the same time, the child's grasp patterns varied depending upon somatosensory inputs from weight shifting. As a consequence, significant improvement in visuomotor coordination and upper-limb speed and dexterity could be achieved.

The finding that all TSIF scores were increased at T2 and T3 indicates that the SDHRP alone can provide for improved sensory integrative functions as a result of constant practice for integration of visual, vestibular, and proprioceptive inputs. In particular, significant gains in emotion and behavior subtest of the TSIF after SDHRP intervention implies that the playfulness inherent in the SDHRP (Kubota et al., 2006; Spink, 1993) was able to tap into the children's inner drive to engage with Joba® therapy. Active participation on the part of children affects the psychosocial aspect of their development (Tye & Tye, 1992).

We found clear evidence for the effectiveness of regular OT on motor proficiency based on the finding that group B exhibited significant improvement across all BOTMP subtests except strength and running speed and agility between T1 and T2; however, on account of the larger effect sizes for the BOTMP and TSIF in group A at T2 and group B at T3, combined SDHRP and regular OT approaches are strongly suggested to maximize treatment effects for both motor proficiency and sensory integration.

Limitations

The limitations of this study concern a restricted age range and nature (autism) of the sample. Replication with other age groups and other developmental disabilities would increase the clinical utility and confidence in conclusions regarding the use of the SDHRP for improving motor proficiency and sensory integration functions in children with different disabilities.

Recommendations for Further Study

Future work is needed to determine the optimal treatment frequency with the SDHRP by comparing the efficacy of different treatment schedules on sensory integrative and motor functions of children with autism. Follow-up studies are also warranted to investigate the predictive relationship between the SDHRP in children with autism to functional outcomes in domains such as physical education and school functions.

Conclusion

Children with autism in this study showed improved motor proficiency and sensory integrative functions after SDHRP training for a period of 20 weeks in duration, 2 sessions per week, and 60 min per session. In addition, the treatment effect appeared to be maintained for at least 6 months (24 weeks). It is concluded that the SDHRP is an effective intervention option for children with autism.

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