

## Effectiveness Studies of Other Interventions Using Sensory or Motor Activities

This section will include summaries from the literature on motor learning, the impact of exercise, and other interventions that would not be considered Ayres' SI intervention because they do not meet the principles as outlined in this website.

2009

**Ginny L. Van Rie & L. Juane Heflin (2009).** The effect of sensory activities on correct responding for children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, Volume 3, Issue 3, p. 783-796,

Sensory-based activities are commonly recommended for students with ASD, even in the absence of empirical data to substantiate their effectiveness. A single subject alternating treatment design was used to assess functional relations between sensory-based antecedent interventions and correct responding in four students with autism. As individuals with autism constitute a heterogeneous population, it is not surprising that a functional relation was found for only two of the four students. Results of this study lead to the conclusion that sensory-based interventions may be effective for some but not all students with autism. Implications for evaluating aptitude by treatment interactions and suggestions for future research are discussed.

**Bart O, Bar-Haim Y, Weizman E, Levin M, Sadeh A, Mintz M.(2009).** Balance treatment ameliorates anxiety and increases self-esteem in children with comorbid anxiety and balance disorder. *Res Dev Disabil.* 30(3):486-95. Epub 2008 Sep 4.

Comorbidity between balance and anxiety disorders in adult population is a well-studied clinical entity. Children might be particularly prone to develop balance-anxiety comorbidity, but surprisingly they are practically neglected in this field of research. The consequence is that children are treated for what seems to be the primary disorder without noticing possible effects on the other disorder. In Study 1, children with balance dysfunction were compared to normally balanced controls on anxiety and self-esteem. In study 2, children with balance dysfunction were assigned to either balance training or a waiting-list control. Training consisted of 12 weekly sessions of balance treatment. Anxiety and self-esteem were tested before and after treatment/waiting. Study 1 confirmed significantly higher anxiety and lower self-esteem in the balance dysfunction group compared to the control group. Study 2

showed that treatment improved balance performance, reduced anxiety, and increased self-esteem relative to the control waiting list group. Taken together, the present findings are in accord with the observations of comorbidity between balance and anxiety disorders in adults and confirm their validity in children younger than 7 years of age. This profile of comorbidity between balance dysfunction and anxiety also include lower self-esteem.

**Lambourne K, Audiffren M, Tomporowski PD. (2009). Effects of Acute Exercise on Sensory and Executive Processing Tasks. Med Sci Sports Exerc. 2009 Dec 14. [Epub ahead of print]**

**PURPOSE::** The immediate and delayed effects of a single bout of steady-state aerobic exercise on 19 young adults' (mean 21.1 years) sensory sensitivity (critical flicker fusion, CFF) and executive function (modified Paced Auditory Serial Addition Task, PASAT) were assessed. **METHODS::** Tests were performed prior to exercise, 5 times during 40 min of ergometer cycling at 90% ventilatory threshold, and 3 times during a 30-min post-exercise period. In a separate control session, each participant performed the same sequence of tests while seated on the ergometer without pedaling. **RESULTS::** ANOVAs were performed separately on CFF and PASAT scores, which compared performance during exercise and non-exercise conditions at 9 time points. Planned ANOVAs of CFF scores revealed that participants' sensory discrimination increased during exercise, and then quickly returned to baseline levels immediately following exercise. PASAT scores did not change during or following exercise. **CONCLUSION::** Exercise-induced arousal facilitates sensory processes involved in stimulus detection but does not influence the updating component of executive processing.

**Riethmuller AM, Jones R, Okely AD.(2009). Efficacy of interventions to improve motor development in young children: a systematic review. Pediatrics. 2009 Oct;124(4):e782-92. Epub 2009 Sep 7.**

**OBJECTIVE:** The objective of this study was to systematically review evidence from controlled trials on the efficacy of motor development interventions in young children. **METHODS:** A literature search of interventions was conducted of 14 electronic databases. Three reviewers

independently evaluated studies to determine whether they met the inclusion criteria. Studies were compared on 5 components: design, methodologic quality, intervention components, efficacy, and alignment with the Consolidated Standard of Reporting Trials (CONSORT) and Transparent Reporting of Evaluation with Nonrandomized Designs (TREND) statements. RESULTS: Seventeen studies met the inclusion criteria. More than half (65%) were controlled trials and delivered at child care settings or schools (65%). Three studies had high methodologic quality. Studies were approximately 12 weeks in duration and delivered by teachers, researchers, and students. Parents were involved in only 3 studies. Nearly 60% of the studies reported statistically significant improvements at follow-up. Three studies aligned with the CONSORT and TREND statements. CONCLUSIONS: This review highlights the limited quantity and quality of interventions to improve motor development in young children. The following recommendations are made: (1) both teachers and researchers should be involved in the implementation of an intervention; (2) parental involvement is critical to ensuring transfer of knowledge from the intervention setting to the home environment; and (3) interventions should be methodologically sound and follow guidelines detailed in the CONSORT or TREND statement.

**Rosenkranz K, Butler K, Williamon A, Rothwell JC. (2009). Regaining motor control in musician's dystonia by restoring sensorimotor organization. *J Neurosci.* 29(46),14627-36.**

Professional musicians are an excellent model of long-term motor learning effects on structure and function of the sensorimotor system. However, intensive motor skill training has been associated with task-specific deficiency in hand motor control, which has a higher prevalence among musicians (musician's dystonia) than in the general population. Using a transcranial magnetic stimulation paradigm, we previously found an expanded spatial integration of proprioceptive input into the hand motor cortex [sensorimotor organization (SMO)] in healthy musicians. In musician's dystonia, however, this expansion was even larger. Whereas motor skills of musicians are likely to be supported by a spatially expanded SMO, we hypothesized that in musician's dystonia this might have developed too far and now disrupts rather than assists task-specific motor control. If so, motor control should be regained by reversing the excessive reorganization in musician's dystonia. Here, we test this hypothesis and show that a 15 min intervention with proprioceptive

input (proprioceptive training) restored SMO in pianists with musician's dystonia to the pattern seen in healthy pianists. Crucially, task-specific motor control improved significantly and objectively as measured with a MIDI (musical instrument digital interface) piano, and the amount of behavioral improvement was significantly correlated to the degree of sensorimotor reorganization. In healthy pianists and nonmusicians, the SMO and motor performance remained essentially unchanged. These findings suggest that the differentiation of SMO in the hand motor cortex and the degree of motor control of intensively practiced tasks are significantly linked and finely balanced. Proprioceptive training restored this balance in musician's dystonia to the behaviorally beneficial level of healthy musicians.

**Niklasson M, Niklasson I, Norlander T. (2009). Sensorimotor therapy: using stereotypic movements and vestibular stimulation to increase sensorimotor proficiency of children with attentional and motor difficulties. *Percept Mot Skills*. 108(3),643-69.**

The current naturalistic study examined whether sensorimotor therapy utilizing the training program, Retraining for Balance, might be an appropriate technique for sensorimotor proficiency. The 232 children (181 boys, 51 girls), whose mean age was 9.3 yr. (SD = 2.7), presented attentional and motor difficulties (according to the School Health Care) as indicated by their parents before starting therapy. The children were divided into three groups, i.e., a younger group (7 yr. old or younger, n = 65), a middle group (8 to 10 yr. old, n = 91), and an older group (11 yr. old or older, n = 76). The program has seven parts, including fetal and neonatal movements, vestibular and auditory perceptual stimulation, and gross motor movements, among others. The treatment period was close to 3 yr. on the average. Analyses in a repeated-measures design indicated significant improvement of sensorimotor skills among the three age groups, but the older children performed better than the others on several tests. There were only a few sex differences. Retraining for Balance may be a functional technique for training children and youth with sensorimotor difficulties and might constitute a complement to regular treatment of Developmental Coordination Disorder, Learning Disability, and ADHD, but controlled studies are necessary before more decisive conclusions can be drawn.

**Tsai CL. (2009). The effectiveness of exercise intervention on inhibitory control in children with developmental coordination disorder: using a visuospatial attention paradigm as a model. Res Dev Disabil.30(6),1268-80. Epub 2009 Jun 3.**

Children with developmental coordination disorder (DCD) have been demonstrated to show a deficit of inhibitory control in volitional shifts of attention. The aim of this study was to use ecological intervention to investigate the efficacy of table-tennis training on treating both problems with attentional networks and motor disorder in children with DCD. Forty-three children aged 9-10 years old were screened using the Movement Assessment Battery for Children and divided into DCD (n=27) and typically developing (TD, n=16) groups. Children with DCD were then quasi-randomly assigned to either a DCD-training group who underwent a ten-week table-tennis training program with a frequency of 3 times a week or a DCD non-training group. Before and after training, the capacity of inhibitory control was examined with the endogenous Posner paradigm task for DCD and TD groups. Table-tennis training resulted in significant improvement of cognitive and motor functions for the children with DCD. The study demonstrated that exercise intervention employed within the school setting can benefit the inhibitory control and motor performance in children with DCD. However, future research efforts should continue to clarify whether the performance gains could be maintained over time.

**Rothlisberger M, Michel E. (2009). [Development and evaluation of a motor coordination training for children in special-needs classes] Prax Kinderpsychol Kinderpsychiatr.58(3),215-30.**

**[Article in German]**

Previous research showed that children in classes with reduced curriculum ("ready for school classes") perform systematically poorer in short-term memory, attention control and motor coordination skills than children in regular classes. Based on these results, a training to improve children's planning, sequencing, and executive control of motor actions was developed. It includes body coordination, (bi-) manual coordination, rhythm and balance. The tasks stress flexibility of action, interference control and focused attention. Training sessions proceed from easy to complex, from action accuracy to speed, and from teacher guidance to

children's self monitoring. Over the course of 3 weeks, 53 children were trained daily for 20 mins. In pre- and posttests, motor coordination was assessed with the M-ABC; focused attention, short-term memory performance, and self-concept was tested with paper-pencil and computerized tasks. Half of the children were trained between pre- and posttest, the other half received the training after posttest. Results revealed no global training effects; however, children in the training condition caught up during training in specific cognitive and motor tasks, and trained children showed a more optimistic self-concept. Training effects were pronounced for children with balance problems. The findings are discussed in terms of reasons for the weak training effects, and potential improvements of the training.

**Rauch F. (2009). Vibration therapy. Dev Med Child Neurol. 2009 Oct;51 Suppl 4:166-8.**

Whole-body vibration training is a method for muscle strengthening that is increasingly used in a variety of clinical situations. Key descriptors of vibration devices include the frequency, the amplitude, and the direction of the vibration movement. In a typical vibration session, the user stands on the device in a static position or performs dynamic movements. Most authors hypothesize that vibrations stimulate muscle spindles and alpha-motoneurons, which initiate a muscle contraction. An immediate effect of a non-exhausting vibration session is an increase in muscle power. Most studies of the longer term use of vibration treatment in various disorders have pursued three therapeutic aims: increasing muscle strength, improving balance, and increasing bone mass. In a small pilot trial in children we noted improvements in standing function, lumbar spine bone mineral density, tibial bone mass, and calf muscle cross-sectional area.

#### **Prior to 2009**

**Waternberg N, Waiserberg N, Zuk L, & Lerman-Sagie T. (2007). Developmental coordination disorder in children with attention-deficit-hyperactivity disorder and physical therapy intervention. *Developmental Medicine & Child Neurology*, 49, 920-5.**

Although physical therapy (PT) is effective in improving motor function in children with developmental coordination disorder (DCD), insufficient

data are available on the impact of this intervention in children with combined attention-deficit-hyperactivity disorder (ADHD) and DCD. This prospective study aimed to establish the prevalence of DCD among a cohort of patients with ADHD, characterize the motor impairment, identify additional comorbidities, and determine the role of PT intervention on these patients. DCD was detected in 55.2% of 96 consecutive children with ADHD (81 males, 15 females), mostly among patients with the inattentive type (64.3% compared with 11% of those with the hyperactive/impulsive type,  $p < 0.05$ ). Mean age was 8 years 4 months (SD 2 y). Individuals with both ADHD and DCD more often had specific learning disabilities ( $p = 0.05$ ) and expressive language deficits ( $p = 0.03$ ) than children with ADHD only. Twenty-eight patients with ADHD and DCD randomly received either intensive group PT (group A, mean age 9 y 3 mo, SD 2 y 3 mo) or no intervention (group B, mean age 9 y 3 mo, SD 2 y 2 mo). PT significantly improved motor performance (assessed by the Movement Assessment Battery for Children;  $p = 0.001$ ). In conclusion, DCD is common in children with ADHD, particularly of the inattentive type. Patients with both ADHD and DCD are more likely to exhibit specific learning disabilities and phonological (pronunciation) deficits. Intensive PT intervention has a marked impact on the motor performance of these children.

**Rine, R.M., Braswell, J., Fisher, D., Joyce, K., Kalar, K., & Shaffer, M. (2004). Improvement of motor development and postural control following intervention in children with sensorineural hearing loss and vestibular impairment. *International Journal of Pediatric Otorhinolaryngology*, 68, 1141-1148.**

The effects of an intervention protocol using motor activities and exercise was examined in 21 children with sensorineural hearing loss and bilateral vestibular impairment. The intervention included 30 minute sessions, 3 times a week for 12 weeks with 10 minutes each of 3 out of 4 categories of activities. The categories included eye hand coordination, visual motor training, general coordination, and balance. Pre and post tests were administered to the sample using rotary chair VOR, electrooculography, posturography and the gross motor portion of the PDMS.

**SIGN note:** This treatment protocol would not be considered Ayres' SI because it does not meet the principles as outlined. It was not child directed, did not focus on the provision of appropriate sensory opportunities or the just right challenge for example. However, it does support the idea that interventions that require active movement can

lead to improvements in motor skills even in those with severe sensory processing impairments due to sensory receptor and pathway damage.

**Molteni, R., Wu, A., Vaynman, S., Ying, Z., Barnard, R.J., & Gomez-Pinilla, F. (2004). Exercise reverses the harmful effects of consumption of a high fat diet on synaptic and behavioral plasticity associated to the action of brain derived neurotrophic factor. *Neuroscience*, 123, 429-440.**

One of the important modulators of synaptic plasticity is brain-derived neurotrophic factor (BDNF). BDNF is also a predictor of the efficacy of learning performance in rodents. Diets high in fat and sugar, typical of our Western culture, can reduce the levels of BDNF in the hippocampus (an area of the brain important for memory and learning). In rats, a program of exercise was initiated to examine the effects of exercise on the diet related changes in BDNF. A total of 344 rats were fed a high fat diet and were either able to run on a wheel or not. The exercise of running on the wheel was found to reverse the decrease in BDNF resulting from the high fat diet, and also led to other changes in the brain at the molecular level. The exercise also prevented the typical spatial deficits found in rats exposed to these diets.

**SIGN note:** Of course we do not know how alike we are to rats, but, if the same results can be found in humans, it is yet another reason we need to change our diets. Can our children's diets be hindering their learning?

**Schoemaker, M.M, & Niemeijer, A.S. (2003). Effectiveness of neuromotor task training for children with developmental coordination disorder: A Pilot Study . *Neural Plasticity*, 10, 155-163.**

The authors of this study examined the effectiveness of Neuromotor Task Training (NTT) on children with Developmental Coordination Disorder (DCD). The training consisted of a task-oriented program centered upon the ideals of motor control and motor learning. To examine NTT, 15 children with DCD participated in the study. Ten children participated in the intervention group. These children were assessed with The Movement Assessment Battery for Children (Movement-ABC) and the Concise Assessment Method for Children's Handwriting (BHK) at the start of the study, after nine intervention sessions, and after another nine intervention sessions. The intervention sessions involved individual

treatment sessions for 30 minutes once a week. These treatment sessions followed the principles of NTT and incorporated functional exercises, including both fine and gross motor skills, such as ball catching. Five children participated in the control group. These children participated in no intervention and were assessed with the Movement-ABC and BHK twice with a period of nine weeks in between in order to account for spontaneous improvement. The authors found no improvement in the motor skills of the control group. The intervention group, however, demonstrated improvement in both gross and fine motor skills as measured by the Movement ABC. They also demonstrated improvement in handwriting quality.

**Müller SV, von Schweder AJ, Frank B, Dengler R, Münte TF, & Johannes S. (2002). The effects of proprioceptive stimulation on cognitive processes in patients after traumatic brain injury. *Arch Phys Med Rehabil.*,83, 115-21.**

**OBJECTIVE:** To investigate the hypothesis that proprioceptive stimulation may be effective in the treatment of brain injury, using neurophysiologic and neuropsychologic measures. **DESIGN:** Cohort analytic study. **SETTING:** Patients recovering from traumatic brain injury (TBI) in a neurologic rehabilitation hospital were examined. **PARTICIPANTS:** Eleven patients with TBI (Glasgow Coma Scale score > 3) and 11 healthy control subjects matched for age and education. **INTERVENTIONS:** Subjects were examined with the event-related potential (ERP) technique during a computerized choice-reaction-time task, in which they had to discriminate between even and odd digits. There were experimental runs with and without vibratory stimuli applied to the left forearm serving as proprioceptive stimulation. In addition, ERPs were recorded to vibratory stimuli without any additional task. **MAIN OUTCOME MEASURES:** Outcome measures included latencies and amplitudes of the P300 ERP component and of the late negative component. **RESULTS:** In the passive vibration condition, both groups showed the same ERP distribution. In the choice-reaction-time task, latencies and amplitudes of the P300 differed between the 2 groups. The patient group showed longer P300 latencies, which were shortened by vibratory stimuli. In contrast, the control subjects were not affected by vibratory stimuli. **CONCLUSION:** Our findings support the hypothesis that pathologic cognitive processes after TBI can be improved by proprioceptive stimulation. Muscle vibration has positive effects on pathologically slowed cognitive processes but not in healthy subjects.

Torvinen S, Kannus P, Sievänen H, Järvinen TA, Pasanen M, Kontulainen S, Järvinen TL, Järvinen M, Oja P, & Vuori I. (2002). Effect of four-month vertical whole body vibration on performance and balance. *Med Sci Sports Exerc.* 34, 1523-8.

**PURPOSE:** This randomized controlled study was designed to investigate the effects of a 4-month whole body vibration-intervention on muscle performance and body balance in young, healthy, nonathletic adults. **METHODS:** Fifty-six volunteers (21 men and 35 women, aged 19-38 yr) were randomized to either the vibration group or control group. The vibration-intervention consisted of a 4-month whole body vibration training (4 min.d(-1), 3-5 times a week) employed by standing on a vertically vibrating platform. Five performance tests (vertical jump, isometric extension strength of the lower extremities, grip strength, shuttle run, and postural sway on a stability platform) were performed initially and at 2 and 4 months. **RESULTS:** Four-month vibration intervention induced an 8.5% (95% CI, 3.7-13.5%, P=0.001) net improvement in the jump height. Lower-limb extension strength increased after the 2-month vibration-intervention resulting in a 3.7% (95% CI, 0.3-7.2%, P=0.034) net benefit for the vibration. This benefit, however, diminished by the end of the 4-month intervention. In the grip strength, shuttle run, or balance tests, the vibration-intervention showed no effect. **CONCLUSION:** The 4-month whole body vibration-intervention enhanced jumping power in young adults, suggesting neuromuscular adaptation to the vibration stimulus. On the other hand, the vibration-intervention showed no effect on dynamic or static balance of the subjects. Future studies should focus on comparing the performance-enhancing effects of a whole body vibration to those of conventional resistance training and, as a broader objective, on investigating the possible effects of vibration on structure and strength of bones, and perhaps, incidence of falls of elderly people.

Niemeijer AS, Smits-Engelsman BC, Reynders K, & Schoemaker MM.(2003). Verbal actions of physiotherapists to enhance motor learning in children with DCD. *Hum Mov Sci.* 22, 567-81.

In this study, the motor teaching principles taxonomy (MTPT) was developed to investigate which teaching principles physiotherapists use to treat children with developmental coordination disorder during Neuromotor Task Training (NTT). In NTT, special attention is paid to the best ways to instruct and provide feedback. Based on motor learning theory and video observations of NTT treatments, teaching principles

aimed at improving motor learning were categorised into three categories: giving instruction, providing or asking feedback, and sharing knowledge. The MTPT's reliability and validity were satisfactory. Therapists gave instructions very frequently. In addition, the principle frequency showed hardly any correlation with the children's initial motor performance level, indicating that the principles used are not related to the child's entry level.

#### Other Citations of Interest

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