

EFFECTS OF SENSORY STIMULATION ON PLANTAR FOOT SENSITIVITY AND MOTOR COORDINATION ABILITIES IN CHILDREN

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The purpose of this study was to investigate the effects of sensory stimulation on plantar sensitivity and motor coordination abilities in children. 37 children from 6 to 8 years (6.7 yrs., ± 0.5) participated in the study. The subjects were divided into three groups. The plantar foot of the first group was stimulated by wearing a randomly knobbed insole ('Insole') for 5 weeks. The second group additionally performed a sensory training ('Training & Insole'). The third group ('Control') received no determined stimulation during the 5 weeks. Before and after the stimulation period the sensitivity thresholds and motor coordination abilities were measured. The group 'Training & Insole' showed significant improvements for tactile thresholds after the treatment compared to the control group. For the group 'Insole' no significant improvements of sensitivity thresholds were found. The motor coordination abilities of the group 'Training & Insole' also improved significantly in comparison to the control group, whereas the coordination abilities of the 'Insole' subjects did not improve significantly.

KEY WORDS: stimulation, sensation, sensibility, motor skills, plantar foot, children.

INTRODUCTION:

It is well investigated that human posture and balance are controlled by the somatosensory system in conjunction with the visual and vestibular system (Maurer et al., 2000). Therefore, plantar foot highly contributes to human balance control and posture. The tactile and vibration thresholds of the plantar foot increase significantly with age (Thornbury & Mistretta, 1981). Increased sensitivity thresholds represent reduced sensitivity. Moreover, reduced sensitivity is associated with diseases e. g. Morbus Parkinson (Prätorius & Milani, 2004). Previous studies have shown that five weeks of knobbed insole (Fig. 1) usage significantly improves plantar sensitivity thresholds and balance control of patients with Morbus Parkinson (Kimmeskamp, 2003). Another well documented fact is the decrease of motor skills in children over the last 20-30 years in Germany (Schmidt et al., 2003). Therefore, the purpose of this study was to investigate the effects of different sensory stimulation on plantar sensitivity and motor coordination abilities in children.

METHODS:

37 children (21 males, 16 females) from 6 to 8 years (6.7 yrs., ± 0.5) were examined. The subjects were divided into three groups: 11 subjects were requested to wear a randomly knobbed insole (Fig. 1) as often as possible for five weeks. 11 subjects performed additionally a sensory training (2 times, 45 minutes per week). The training was composed from different exercises, performed with the feet: folding of newspapers, grabbing objects with the feet, painting with the feet, palpation of different subsurfaces etc. Before and after the five weeks of treatment, sensitivity thresholds of the plantar foot and motor coordination abilities were quantified. The remaining 15 subjects composed the control group. During the 5 weeks no determined stimulation was applied to the control group. In order to quantify plantar sensitivity tactile and vibration thresholds of five plantar regions of the foot (heel, arch, 1st and 5th metatarsal head, hallux) were determined. Tactile thresholds were detected with Semmes-Weinstein Monofilaments (North Coast Medical Inc., San Jose, CA)

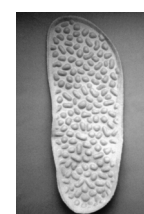


Fig.1: Knobbed Insole

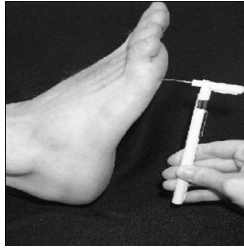


Fig. 2: Semmes-Weinstein Monofilament testing



Fig. 3: Detection of vibration thresholds with a Vibration-Exciter.

(Fig. 2) by use of a modified 4, 2 and 1 stepping algorithm (Dyck, 1999). Vibration thresholds were determined through amplitude increase of a self-constructed Vibration-Exciter at a frequency of 30 Hz (Fig. 3).

Motor coordination abilities were quantified with a standard test for children, the Body Coordination Test (BCT) (Schilling & Kiphard, 1974). The BCT consists of four different tasks: 1. Balancing backwards (BB), 2. One-foot hopping over (HO), 3. Jumping sideways (JS), 4. Shifting platforms sideways (SP) (Fig. 4). From the results of these four tasks the Motor Quotient (MQ) can be calculated by normalizing achieved scores to age and gender. The MQ allows an assessment of the general motor coordination abilities in children (MQ status: very good, good, normal, conspicuous and impaired). For determination of mean tactile and vibration parameters the thresholds of the five regions of the foot were averaged. Data were analyzed with inferential statistics (t-tests).



Fig. 4: Body Coordination Test (BCT)

RESULTS:

Changes within the test groups

Between the pre and post measurements the different treatments led in both test groups to improvements of plantar sensitivity thresholds. The group 'Training & Insole' showed a significant decrease of mean tactile thresholds (MTT) and mean vibration thresholds (MVT) after the treatment (Fig. 5, 6). For the test group 'Insole' only the MVT improved highly significant (Fig. 6).

Sensory stimulation also improved motor coordination abilities in both test groups between the pre and post measurements. The overall MQ of the 'Training & Insole' group was significantly higher after the five weeks of treatment. Considering the four single test items of the BCT the mean results of all 4 tests were better (Fig. 7). BB and JS improved statistically significant ($p < 0.05$). BCT parameters of the 'Insole' group also improved except JS, but statistically not significant (Fig. 8).

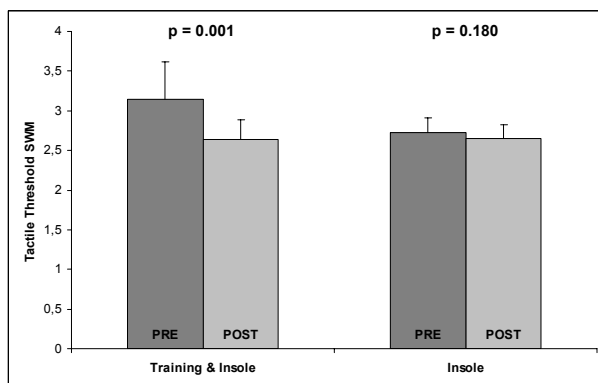


Fig. 5: Mean tactile thresholds for test groups

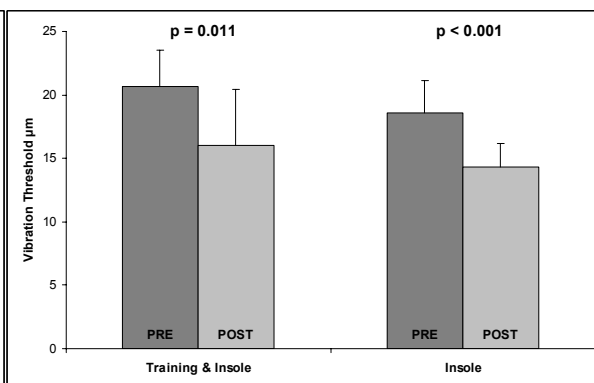


Fig. 6: Mean vibration thresholds for test groups

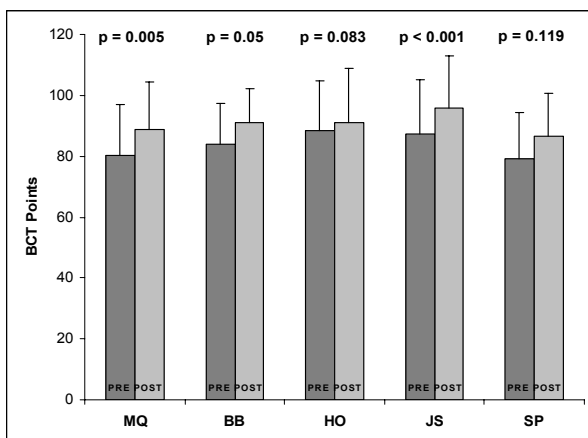


Fig. 7: BCT Parameters for group 'Training & Insole'

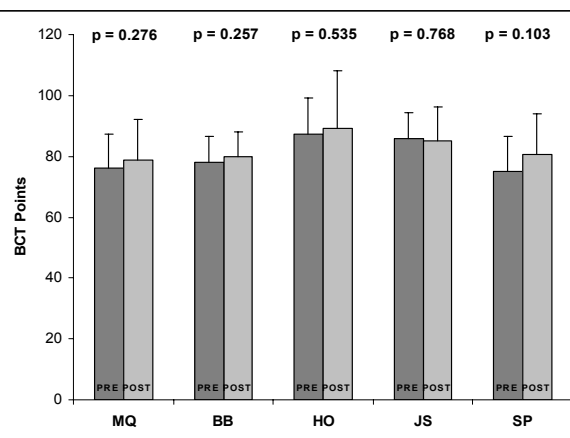


Fig. 8: BCT Parameters for group 'Insole'

Differences between the groups

In comparison to the control subjects only group 'Training & Insole' showed a significant difference for mean tactile thresholds ($p = 0.019$). No significant differences could be proved for mean vibration thresholds in both test groups. The motor coordination abilities of the 'Training & Insole' subjects showed significant differences for MQ ($p = 0.001$), BB ($p = 0.006$), JS ($p = 0.008$) and SP ($p = 0.02$) compared to control subjects. In group 'Insole' only for BB ($p = 0.006$) and SP (0.021) significant differences could be proved. Testing the mean differences between group 'Training & Insole' and group 'Insole' MTT ($p = 0.001$) and JS ($p = 0.011$) showed a significant difference.

DISCUSSION:

The purpose of the study was to investigate the effects of different sensory stimulation methods on the plantar foot sensitivity and motor skills of children. In literature it has been shown, that the sensitivity levels of children are the highest compared to adults and seniors (Prätorius & Milani, 2004). The present study provided evidence that the high plantar sensitivity level of children can still be enhanced by sensory stimulation. In the group 'Training & Insole' MTT improved significantly ($p = 0.019$) in comparison to the control group. However, the improvement of the MVT in this group was not significant. Group 'Insole' showed no significant changes in reference to all sensitivity thresholds after the 5 weeks of stimulation in comparison to the control group. In the present study 'Insole' usage without additional sensitivity training did not improve plantar sensitivity statistically significant. Between pre and post measurements MVT improved significantly in all groups (incl. control group). As a result of the homogenous age distribution an explanation for the MVT

improvements in all groups may possibly be physical ontogenetic changes of the subjects. The rapid physical development at this age might include the proven improvements of MVT. The importance of the somatosensory system on human balance control is well known, but the influence of plantar sensitivity on general motor skills is not well investigated. Results of this study indicate that enhancing plantar sensitivity can be a possibility to significantly improve motor coordination abilities of children. All motor coordination parameters except HO of the 'Training and Insole' subjects improved significantly in comparison to the control group. In the 'Insole' group only BB and SP improved significantly. A significant increase on gait and balance control from Morbus Parkinson patients was achieved by wearing the knobbed insoles (Kimmeskamp, 2003; Prätorius et al., 2002). Improvement of children's motor coordination abilities seems to be more complex. The different base levels of sensitivity thresholds in children and Morbus Parkinson patients may be an explanation for this finding. The extent of the effects of successful plantar sensitivity enhancement on motor coordination abilities in the group 'Training & Insole' was surprising. JS, a motor test most likely determined by muscular endurance, improved highly significant. At the time an explanation for this finding cannot be given. Moreover, neither an explanation why improvement exclusively of MVT like in group 'Insole' does not enhance motor coordination abilities of children to the same extent like MVT and MTT enhancement (group 'Training & Insole') nor a theory of the possible interaction between the different receptors in plantar foot in regard to motor skills could be found in the literature.

CONCLUSION:

The results of the study show that high plantar sensitivity levels of children can still be improved by sensory stimulation. The present data demonstrate that wearing a stimulating insole and additionally performing a sensory training is more efficient than using knobbed insoles only: the motor coordination abilities of subjects treated with training and insole were significantly improved after five weeks of treatment. Therefore, sensitivity training and insole use may be an alternative and motivating way to treat motor deficits in children. Further studies are needed to understand the relation between stimulation method and effect on plantar foot. Moreover, the possible effects of improved plantar sensitivity on motor skills and human coordination have to be investigated in the future.

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