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**Effectiveness of sensory integration therapy in children, focusing on Korean children:
A systematic review and meta-analysis**

Meta-Analysis Sensory Integration : Korean Children

Abstract

BACKGROUND

Sensory integration intervention is highly related to the child's effective interaction with the environment and the child's development. Currently, various sensory integration interventions are being applied, but research methodological problems are arising due to unsystematic protocols. This study aims to present the optimal intervention protocol by presenting scientific standards for sensory integration intervention through meta-analysis.

AIM

This study conducted a meta-analysis to prove the effectiveness of sensory integration therapy, examine the latest trend of sensory integration studies in Korea, and provide clinical evidence for sensory integration therapies.

METHODS

The database of Korean search engines, including RISS, KISS, and DBpia, was used to search for related literature published from 2001 to October 2020. The keywords, "Children", "Sensory integration", "Integrated sensory", "Sensory-motor", and "Sensory stimulation" were used in this search. Then, a meta-analysis was conducted on 24 selected studies. RISS, KISS, and DBpia, was used to search for related literature published

from 2001 to October 2020. The keywords, “Children”, “Sensory integration”, “Integrated sensory”, “Sensory-motor”, and “Sensory stimulation” were used in this search. Then, a meta-analysis was conducted on 24 selected studies

RESULTS

Sensory integration intervention has been proven effective in children with cerebral palsy, autism spectrum disorder, attention deficit/hyperactivity disorder, developmental disorder, and intellectual disability in relation to the diagnosis of children. Regarding sensory integration therapies, 1:1 individual treatment with a therapist or a therapy session lasting for 40 minutes was most effective. In terms of dependent variables, sensory integration therapy effectively promoted social skills, adaptive behavior, sensory processing, and gross motor and fine motor skills.

CONCLUSION

The results of this study may be used as therapeutic evidence for sensory integration intervention in the clinical field of occupational therapy for children, and can help to present standards for sensory integration intervention protocols.

Key Words: Children; Meta-analysis; Occupational Therapy; Sensory integration; Sensory processing; Social skills

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Core Tip: This study conducted a meta-analysis to prove the effectiveness of sensory integration therapy, to examine the latest trends in domestic sensory integration studies, and to provide clinical evidence for sensory integration therapy. A meta-analysis was conducted on 24 selected studies. Sensory integration therapy has been proven effective

in children with cerebral palsy, autism spectrum disorder, attention deficit/hyperactivity disorder, developmental disorder, and intellectual disabilities in relation to the diagnosis of children. Sensory integration therapy was most effective in 1:1 individual treatment with the therapist, or a treatment session that lasted 40 minutes. In terms of dependent variables, sensory integration therapy effectively promoted sociality, adaptive behavior, sensory processing, total amount of exercise, and fine motor ability.

INTRODUCTION

Sensory integration is a neurological process that organizes sensory input so that it can interact efficiently within a given environment^[1]. Also, sensory integration therapy enables the reception of various sensory stimulation, including visual, auditory, tactile, proprioceptive sense, and vestibular sense to achieve effective interaction between the child and the environment, and eventually result in a proper cognitive, motor behavioral, and emotional development^[2-3]. If this sensory integration is impaired, environmental stimulation cannot be properly accepted, or the development of the learning potential of changing the environment in response to stimulation is disabled. As a result, performing such activities may require excessive focus and effort, and may result in difficulty in functional performance in daily life ^[4-5].

A variety of sensory integration therapy is applied to address the difficulties due to sensory integration disabilities. Sensory integration therapies provide child customized play and controlled sensory experience within the behavioral therapy setting ^[6]. Intervention is performed under the principle in which the vestibular, tactile, and proprioceptive senses play a main role, and effective processes and integrate senses^[7]. As a result, appropriate posture control, maintaining of muscle tone, and emotional stability are developed and can bring about promotion praxis and sensory processing that are the basis of improving skills for activities of daily living and social participation, such as peer play, daily life activities, and learning^[8].

So far, although studies that apply sensory integration therapy to children with various diseases have been conducted ^[2, 9-11], the effectiveness of sensory integration therapy and

its evidence have been controversial ^[12,13]. The main reason for the continuing controversy is the disparity in the way sensory integration therapy is applied in each study ^[14]. The methodology is being challenged due to disorganized protocol and inconsistent use of terminology ^[15,16]. Therefore, a process was needed to establish a treatment protocol by presenting consistent and scientific criteria for sensory integration therapy based on evidence-based studies that prove its effectiveness^[17].

Meta-analysis and systematic review are two of the most objective and scientific research methods to prove the effectiveness of a study^[18]. A meta-analysis statistically integrates various quantitative results from studies on an identical subject of study and transfers those to affect size in comprehensively analyzing various study results^[19]. A summary using meta-analysis increases the number of samples by integrating the study results, thereby minimizing the distortion and error of each study and increasing statistical power. Likewise, it enables identifying factors that affect the study result when there is heterogeneity between the results of each study and suggests a total numerical value as robust evidence to enable an objective deduction ^[20,21].

Previous meta-analysis studies on sensory integration therapy have mostly focused on the change in dependent variables, such as behavior, learning, motor skills, and sensory processing ^[22-24]. Since they lacked analysis on the method of intervention, including the duration of treatment and the effectiveness by type and diagnosis, a study of such magnitude was necessary. Therefore, this study aims to prove the effectiveness of sensory integration therapies through a meta-analysis of sensory integration therapy in children from 2001 through 2020 and to provide fundamental data required for the establishment of theoretical evidence and systematic protocols for future sensory integration therapies.

MATERIALS AND METHODS

II. Materials and methods

This study used meta-analysis to analyze the effectiveness of sensory integration therapy through studies on sensory integration therapy in children. All processes of this

study were conducted according to the procedures after receiving approval from the Kangwon National University Institutional Review Board (KWNUIRB-2021-12-002).

1. Literature Search

The literature search was conducted from October 24 to October 26, 2020, and targeted literature that was published from 2001 to October 2020 in Korea. Korean databases, including RISS (Research Information Sharing Service) provided by Korea Education and Research Information Service, DBpia engineered by Nurimedia, and KISS (Korean Studies Information Service System) provided by Korean Studies Information, were used for the online literature search. The keywords, "Children" AND "Sensory integration", "Integrated sensory", "Sensory-motor", and "Sensory stimulation" were used. The review was conducted by two individual investigators, and any disagreements on the review articles were put under author discussion and selection.

2. Study Selection and Data Extraction

The inclusion criteria of subject literature were done first, including studies published as domestic theses; secondly, studies that applied sensory integration therapy either by group or 1:1 session; third, two-group comparison studies consisting of both test group and control group; and fourth, studies of which the test data and full text are made available. Studies conducted on adults, not children, single case studies, studies of which the resulting data and full test are not available, single group experimental studies without control groups, studies using medication and review literature, and qualitative studies were excluded.

Figure 1 shows the study selection process. A total of 6,362 studies were found in the Korean database after using the preselected keywords. Based on the second search, the titles and abstracts of the studies were reviewed, and a total of 91 studies were selected, excluding studies that did not meet the inclusion criteria and duplicates. Then, the full text of the 91 studies was reviewed to exclude a total of 67 non-conforming studies (5

studies where children were not targeted for sensory integration therapy, 28 single case studies, 4 studies of which the full text was not available, 13 studies that did not present necessary data, including mean and standard deviation, and 17 studies without a control group), resulting in a total of 24 studies selected for meta-analysis. The contents of the selected studies are shown in Table 1.

Figure 1 & Table 1

3. *Methodological Quality*

To improve the quality of the study in accordance with AMSTAR (Assessment of Multiple Systematic Reviews), a search was conducted for academic literature, including theses. The level of evidence model, which consist of 5 Levels developed by Arbesman, Scheer, and Lieberman (2008)^[25], was used to assess the quality level of 24 studies that were selected after reviewing the full text. The level of evidence starts from the highest level of evidence, Level 1 up to Level 5, and the studies were classified under these levels. For the qualitative level of evidence of the studies selected, 3 studies (12%) were Level 1 (Randomized controlled trial), and 21 studies (88%) were Level 2 (Non-randomized two-group studies) (Table 2).

Table 2

4. *Data Analyses*

A meta-analysis was performed on the selected studies that were encoded with their characteristics. A significance test on Q statistics was conducted by performing a Chi-square test to evaluate statistical heterogeneity, where a p-value lower than 0.10 indicated statistical heterogeneity ^[26]. Based on the statistical heterogeneity of each study, the random-effect model was applied in the presence of heterogeneity, and the fixed-effect model was applied in case of homogeneity, while the calculated effect sizes were summarized in a forest plot ^[27]. An effect size in a meta-analysis is a standardized indicator of the extent of difference between efficacies and relation. An effect size not less than 0.8 indicates a large effect; an effect size of about 0.5 indicates a medium effect; and an effect size of 0.2 or smaller indicates small effect ^[28].

The software program (CMA version 3) was used to conduct the meta-analysis. The effect size was calculated to determine the effect of sensory integration therapy in total, the effect of group and 1:1 individual sensory integration therapy, the effect of sensory integration therapy by diagnosis, and the effect of sensory integration therapy based on the duration of treatment.

RESULTS

III. Results

1. Effect Size by Diagnosis and Study Design

For the effect size of sensory integration therapy by diagnosis, the effective size was largest in CP [1.50(CI: 1.25~1.74)], followed by ASD [1.35(CI: 0.96~1.71)] and ADHD [1.06(CI: 0.75~1.38)]. The effect size was determined as medium as 0.48(CI: 0.38~0.58) for developmental disability, and as small as 0.14(CI: -0.05~0.34) for intellectual disability (Table 2)

For the effect size by study design, both 1:1 Individual treatment [0.50(CI: 0.43~0.57)] and Group treatment [0.26(CI: 0.05~0.47)] had medium effect size. For the duration of intervention, the effect size was small and negative for the duration of 30 minutes [-0.01(CI: -0.13~0.11)], and larger for the duration of 40 minutes [0.88(CI: 0.77~0.99)] (Table 3).

Table 3

2. Effect Size by Dependent Variable

Studies subject to analysis were narrowed down to 24 studies and categorized into 5 areas, including social skill, adaptive behavior, gross motor, fine motor, and sensory processing to identify the effect of sensory integration therapy on child function. By area, the largest number of studies was on gross motor, with 12 studies on gross motor, 8 on

sensor processing, 5 on social skill and fine motor, and 3 on adaptive behavior. The effect size was largest in social skill, followed by adaptive behavior, sensory processing, gross motor, and fine motor, where the effect size was large for social skill, adaptive behavior, and sensory processing, and medium for gross motor and fine motor (Table 4, Figure 2-6) [29-47].

Table 4 & Figure 2-6

For the effect size of specific sensory integration therapy by dependent variables, a statistically significant effect size was proven in all five areas ($p < 0.05$) [Figure 2]. The effect size was as large as 1.22 (CI: 1.06~1.39) for social skill function, and heterogeneity was as high as 96%. The effect size for adaptive behavior was as small as 0.15 (CI: 0.05~0.25), and heterogeneity was as high as 95%. The effect size for sensory processing was as large as 0.85 (CI: 0.71~0.98), and heterogeneity was as high as 97%. The effect size for gross motor was medium at 0.26 (CI: 0.18~0.35), and heterogeneity was as high as 95%. The effect size of sensory integration therapy on fine motor was as large as 0.25 (CI: 0.14~0.35), and heterogeneity was as high as 92%.

DISCUSSION

IV. Discussion

Sensory integration is a theory in which adaptive behavior is induced by the relationship between the behavior and the neurological process based on the neurological activity in the central nervous system. It is applied and studied in various ways in clinical settings. Its efficacy is reported to be different based on the approach practiced by the therapist and its purpose. Therefore, this study was conducted to establish clinical evidence for sensory integration therapy by verifying the effectiveness of previous studies by using meta-analysis and providing fundamental data that will be useful for

systematic protocol determination, and, eventually, improving the quality of occupational therapy.

This study analyzed 24 studies on sensory integration therapy published in Korea from 2001 to 2020.

First, the studies were randomized controlled studies (Level 1) or non-randomized two-group studies (Level 2), which were of high level of evidence in the qualitative analysis. Previous systematic review and meta-analysis studies were performed with articles of different qualitative levels of evidence, which resulted in the inconsistency of results. Whereas, this study only included studies with a high level of evidence to improve the level of clinical evidence.

For the meta-analysis by diagnosis and study design, CP (1.50) had the highest effectiveness, followed by ASD (1.35), ADHD (1.06), developmental disability (0.48), and intellectual disability (0.14). A variety of disease groups in children was not considered in previous studies, as the target diagnosis was set to mental disabilities, whereas this study included various disease groups, and analyzed the effect size by diagnosis to define the effectiveness of sensory integration therapy. Thus, sensory integration therapy was shown as being more effective for children with CP, ASD, and ADHD, based on the differences in individual ability and function, and purpose and method of intervention for each diagnosis. Also, further study is necessary as in previous studies on children with ASD, in which the effectiveness of sensory integration is defined in studies where only sensory integration was applied for treatment. Whereas, the effectiveness of sensory integration therapy is reported to be relatively low in studies comparing sensory integration with other intervention methods. In terms of the effect size by study design, effectiveness was larger for the intervention duration of 40 minutes (0.88) compared to 30 minutes (-0.01), and larger in 1:1 individual treatment (0.50) compared to group treatment (0.26). This leads to similar results to previous studies that reported effectiveness is higher when individual treatment is given at a duration of 60 minutes or longer.

Third, regarding the meta-analysis result by dependent variables, the largest effect was observed in social skills (1.22), followed by adaptive behavior (1.15), sensory processing

(0.85), gross motor (0.26), and fine motor (0.25), indicating that sensory integration therapy is more effective in improving social skill, adaptive behavior, and sensory processing compared to motor function. This result contrasted with the former study, which reported that high effectiveness towards motor function was observed when sensory integration therapy was given under conditions of retardation, including CP. Also, although most of the studies presented conventional social skill improvement programs, including verbal or cognitive behavioral approaches^[22,48], this study showed that sensory integration therapy is also an effective intervention to improve social skills and adaptive behavior. Taking into consideration that individual therapy was more effective compared to group therapy, the improvement of communication with the therapist and understanding of demands through intervention customized for children in 1:1 sessions were considered to have posed greater effect on social skills and adaptive behavior. Therefore, it is recommended for future studies to utilize the control group and to apply various methods and dependent variables to prove the efficacy of sensory integration therapies.

This study has several limitations. First, it included non-randomized, two-group studies, instead of all randomized controlled trials. While the quality of the research results may be low at the time of data collection, the final selected studies included 3 randomized controlled trials. A two-group non-randomized study was included due to difficulty of analysis. However, according to the 5 Levels of evidence developed by Arbesman, Scheer, and Lieberman(2008), the two-group non-randomized study offers a high level of evidence at level 2, providing support that the results of this study can be trusted.

The second limitation is that the studies are published only in Korea. First, the studies had the same cultural background as there was a lack of controlled studies on sensory integration therapies, and differences in cultural backgrounds were not covered since there were no established standard protocols. Thus, studies should be analyzed based on various cultural backgrounds based on this study result to ensure a broader effectiveness analysis of sensory integration therapies. Moreover, if an effectiveness analysis is

performed on sensory integration therapies, including studies comparing sensory integration therapies and other interventions, it will help occupational therapists in applying evidence-based sensory integration therapy in the clinical setting.

CONCLUSION

IV. Conclusion

This study on the effectiveness of sensory integration therapy sought to examine the latest trend in studies on sensory integration therapies in Korea, and to propose therapeutic evidence.

Results confirmed that sensory integration therapies were effective in diagnosing children with CP, ASD, ADHD, developmental disability, and intellectual disability. Regarding sensory integration therapy approaches, 1:1 individual treatment with a therapist or a therapy session lasting for 40 minutes was most effective. A greater effect was observed in terms of social skills, adaptive behavior, and sensory processing function.

The results of this study may be used as therapeutic evidence for sensory integration therapy in children in occupational therapy practices and in standardization of effectiveness analysis through the diagnosis of children. The type of intervention will be useful in providing a practical standard for sensory integration therapy protocols. Based on the limitations of this study, the detail and progress of sensory integration therapies are analyzed more specifically, and adequate multi-national RCTs can be accumulated in future studies to further demonstrate the effectiveness of sensory integration therapies. Also, further meta-analysis study is required not only for studies on the method of sensory integration therapies, but for various intervention methods that combine sensory integration therapy and other interventions.

ARTICLE HIGHLIGHTS

Research background

Sensory integration is a neurological process that allows the child to interact effectively with the environment through stimulation of various senses. Difficulties in sensory integration lead to difficulties in functional performance in daily life.

Research motivation

Recent studies have methodological problems due to different sensory integration intervention methods for each study and unsystematic protocols. Therefore, evidence-based research is needed to prove treatment effectiveness.

Research objectives

The purpose is to confirm the effectiveness of sensory integration intervention, present basic data for a systematic protocol, and prepare a theoretical basis.

Research methods

To analyze the effects of sensory integration interventions, a meta-analysis method was used to investigate the effects of sensory integration interventions through papers published from 2001 to 2020 targeting children.

Research results

Through this study, the effectiveness of sensory integration intervention was confirmed, and based on this, it is believed that it will be helpful in applying evidence-based sensory integration intervention in clinical settings. As a limitation, there are differences depending on cultural background in literature published in Korea, so it is recommended to conduct research based on various cultural backgrounds in the future.

Research conclusions

The sensory integration intervention method proposed in this study is more effective for subjects with cerebral palsy, autism spectrum disorder, and attention deficit

hyperactivity disorder, and is more effective when performed as a 1:1 individual treatment for 40 minutes.

Research perspectives

It would be even more helpful to analyze the effectiveness of sensory integration interventions, including studies that applied not only sensory integration interventions but also other interventions based on diverse cultural backgrounds.

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