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Original Research

Sensorimotor-Enhanced Shoulder Stabilization Exercises to Improve Their Hand Function in Children with Down Syndrome

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ABSTRACT

Background: *Down syndrome is a condition of a genetic disorder caused by an abnormality of chromosome 21. Statistical data shows that the average incidence of Down syndrome worldwide is 1 in every 700 births. This incident will increase with the increasing age of pregnant women. This study aims to compare the addition of sensory motor training to shoulder stabilization exercise to further improve upper extremity strength and fine motor coordination in the Down syndrome population.*

Methods: *This research is an experimental study with blocked randomization. Group 1 (n=15) given the combination of sensorimotor exercises and shoulder stabilization exercise, while the Group 2 (n=15) were given shoulder stabilization exercise. The sampling technique used in this study was purposive sampling. The intervention was given 3 times a week for 4 weeks. Measurements were carried out using the manual muscle test (MMT) and the manual abilities classification system (MACS). Data were analyzed using Wilcoxon Test and the Mann–Whitney U test to compare differences between the two independent groups.*

Results: *The MMT value was p=0.037 (p<0.05) and the MACS value was p=0.041 (p<0.05). These results indicate a significant difference between the two groups.*

Conclusion: *Adding sensorimotor training in shoulder stabilization exercise intervention can improve upper extremity strength and fine motor coordination in down syndrome population. It is suggested to add sensorimotor training in down syndrome population.*

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INTRODUCTION

In Indonesia, Down Syndrome (DS) occurs in approximately 1 out of every 600 live births. A significant factor linked to DS incidence is the mother's age during pregnancy. The risk of having a child with DS increases notably in women over the age

of 35, with the likelihood rising as maternal age advances. For instance, women who give birth at age 40 have a 1 in 106 chance of having a baby with DS, and this risk escalates to around 1 in 11 by the age of 49 (Lestari et al., 2025).

Down Syndrome is associated with a range of clinical features, including intellectual impairments, congenital heart defects, and abnormalities in the endocrine, gastrointestinal, and immune systems, along with characteristic facial features. It is a leading cause of intellectual disability worldwide, with millions affected by experiencing various health challenges such as difficulties with learning and memory. These associated conditions occur regardless of race, nationality, religion, or socioeconomic background (Lestari et al., 2025).

Children with DS are usually 5-18 years, generally experience delays in terms of motor skills. Delays that often occur include weakness in the upper extremities and lack of fine motor coordination such as pinching, tearing, grasping, and writing. Fine motor skills are essential for achieving independence in daily tasks, self-care, and academic activities. In children with DS, the development of fine motor skills can be delayed, partly due to cognitive impairments. Additionally, conditions like hypotonia (low muscle tone) and/or joint hypermobility in the hands, wrists, or elbows can hinder their ability to carry out fine motor tasks. Neuromuscular issues—such as hypotonia, persistent primitive reflexes, and slow voluntary movements—also contribute to difficulties with motor control, functional activities, and balance (Hartono et al., 2024).

Recent research discussing increasing upper limb strength and fine motor coordination in children with DS states that shoulder stabilization exercises can stabilize the shoulder girdle muscles which then impact on hand grip strength and rhythmic movement of the fingers. Shoulder stabilization exercises aim to activate all upper extremity muscles including stabilizing the shoulders and elbows which have an impact on the grip strength and rhythm of the fingers (Elserty & Wagdy, 2020). Shoulder stabilization exercises also have the potential to improve postural control and proximal stability, which are necessary to support fine motor coordination and hand function in children with DS.

Research developments in interventions for children with DS indicate that a combination of exercise approaches can provide more optimal results than a single method. The integration of shoulder stabilisation exercises with sensorimotor stimulation is considered to have a synergistic effect because both target muscle strength, movement control, and sensory integration simultaneously. This multimodal approach has the potential to improve children's ability to perform activities that require fine coordination and proximal stability, thereby supporting increased independence in daily activities and academic tasks.

Thus, testing the effectiveness of adding sensorimotor exercises to the shoulder stabilisation protocol is important to understand the contribution of each intervention to improving the motor function of children with Down Syndrome (Rapisa & Damastuti, 2020). Approaches to the sensorimotor aspects can also help motor coordination. Recent research states that sensorimotor exercises are significant in improving motor coordination. The series of sensorimotor exercises aims to optimize the biological processes in the muscles in processing various sensory and motor information, which is then used as well as possible, especially in increasing motor capacity in children with DS (Rapisa & Damastuti, 2020).

The research problem of this study is whether the addition of sensorimotor exercises to shoulder stabilization exercise further increases upper extremity strength and fine

motor coordination in the DS population. This study aims to determine whether incorporating sensorimotor exercises into shoulder stabilization training can improve upper extremity strength and fine motor coordination in children with Down syndrome. The results of this study are expected to provide scientific evidence regarding the benefits of combining sensorimotor exercises and shoulder stabilization training as a rehabilitation strategy to improve hand function and support children's independence in daily activities.

MATERIALS AND METHOD

This study is an experimental study with blocked randomization. A blocked randomisation experimental design was chosen to ensure a balanced distribution of participant characteristics across groups, thereby making the intervention comparison results more valid. This method also minimises selection bias, allowing for a more accurate evaluation of the intervention's effects on the population of children with special needs (Dahlan, 2021). The study was carried out in Private Development Clinics for children with special needs in Denpasar and Badung areas from July to August 2022.

The population in this study consisted of all children with Down syndrome aged 5–18 years undergoing therapy at growth and development clinics in the Denpasar and Badung areas. The sample size calculation in the research was obtained using the (Pocock, 2008) formula. The number of subjects was determined based on previous research by (Arianti & Fitri, 2018) which examined the effectiveness of play therapy on the fine motor skills of children with Down syndrome.

The standard deviation and mean values of previous research include $\sigma = 5.35$; $\mu 1 = 5.08$, $\mu 2 = 12.46$. From the calculation results, a sample of 12 children per group was obtained. To anticipate the risk of dropout, researchers added 25% to the number of samples obtained. The sample was 15 subjects per group, and the total sample size was 30 subjects.

The sampling technique used in this study was purposive sampling, as subjects were selected based on specific characteristics relevant to the research objectives. The inclusion criteria for this study were: (1) Children are able to stand and walk independently; (2) Have no visual or hearing impairments; and (3) Understand instructions. While the exclusion criteria: (1) Experiencing pain and/or neurological symptoms of the upper or lower extremities; (2) Cervical injuries and chest wall abnormalities; (3) Experiencing Rheumatic and congenital heart disease; (4) Children with a history of surgical operations; and (5) Having regular participation in every sports activity. Criteria for dropping out: (1) Not doing therapy 2 times in a row, (2) Samples who suddenly suffered injuries during the study, and (3) The patient's condition worsened when the intervention was given.

Treatment group I received sensorimotor training and shoulder stabilization exercise intervention, while treatment group II received shoulder stabilization exercise intervention. Intervention was given 3 times a week for 4 weeks. Shoulder stabilization exercise training is applied by maintaining each position in various ranges of motion of the shoulder for 10 seconds.

Each movement is done for 10 repetitions with 3 sets and 3 seconds rest for each repetition. Exercises are carried out 3 times a week for 4 weeks (Elserty & Wagdy, 2020). The sensorimotor exercises consist of 10 series of activities, namely '*meronce',* running following the line, jumping, throwing objects towards the basket, imitating pictures, assembling puzzles, putting water in bottles, eating various kinds of fruit, cutting patterns,

and playing with sand. Exercises are carried out 3 times a week for 4 weeks (Rapisa & Damastuti, 2020).

Researchers select participants by block randomization. The study was conducted with 30 participants. Research participants were divided into two treatment groups. Before the intervention (pre-test) and after the intervention (post-test) an examination of upper extremity strength was carried out which was measured by the Manual Muscle Test (MMT) (Ince et al., 2020). In this study, hand strength was measured by elbow flexion. The results of this measurement consist of 5 scales, namely: Score 0 which means there is no muscle contraction and movement; Score 1 which means there is muscle contraction but no movement; Score 2 which means able to move with a full range of motion, but not yet able to resist gravity; Score 3 which means able to move with a full range of motion, able to resist gravity but not yet able to resist resistance; Score 4 which means able to move with a full range of motion, able to resist gravity and able to resist minimal resistance; and Score 5 which means able to move with a full range of motion, able to resist gravity and able to resist optimal resistance (Manikowska et al., 2018).

Fine motor coordination in this study was assessed using the Manual Abilities Classification System (MACS). MACS is generally used to assess children's hand functions in daily activities. This assessment consists of five levels: level 1, which means they can handle objects easily and successfully; level 2, which means they can handle objects but require time; level 3, which means they need some assistance and sometimes adaptive equipment to handle objects independently; level 4, which means they need continuous assistance and adaptive equipment; and level 5, which means they need total assistance. In this study, MMT and MACS were measured by field assistant physiotherapists (Eliasson et al., 2006; Skoutelis et al., 2020).

The results of the pre-test and post-test were tested using statistical tests using the Statistical Program for Social Science (SPSS). The data analysis to be carried out includes: (1) Normality test, (2) Homogeneity test (distribution of data homogeneity), (3) Comparative Analysis, and (4) Difference Test. This analysis was conducted to determine changes before and after the intervention.

The researcher applied for an ethical permit to the ethics committee of the Faculty of Medicine, Udayana University (No: 1858/UN14.2.2.VII.14/LT/2022). All research procedures were carried out with the utmost respect for the principles of confidentiality, anonymity, and data security of participants. In addition, researchers ensured that parents or guardians of children provided written consent (informed consent) after receiving a full explanation of the objectives, procedures, benefits, and potential risks of the research.

RESULTS

The research findings are comprehensively presented and described in Table 1 and Table 2.

Table 1. Characteristics of Participants in Group 1 and Group 2 **(n = 30)**

Characteristics	Group 1 (n = 15)	Group 2 (n = 15)
Sex, n (%)		
Male	7 (46.7%)	6 (40.0%)
Female	8 (53.3%)	9 (60.0%)
Age (years)		
Mean ± SD	11.40 ± 5.20	10.50 ± 3.30

Note: n = number of participants; SD = standard deviation.

It was found that the number of samples in Group 1 were 7 men (46.7%) and 8 women (53.3%), based on the results of the descriptive test. Whereas in Group 2 there were 6 men (40%) and 9 women (60%). For the age of the sample in group 1, the average was 11.3 ± 5.2, while in group 2 it was 10.5 ± 3.3. (Table 1).

Table 2. Pre- and Post-Test Comparison of the Manual Abilities Classification System (MACS) and the Manual Muscle Test (MMT) Scores Within and Between Groups (n = 30)

Variable	Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Change	Wilcoxon Test (p-value)	Mann–Whitney U Test (p-value)
MACS	Group 1	3.40 ± 0.82	2.22 ± 0.67	–1.18	<0.001	0.037
	Group 2	3.27 ± 1.03	2.93 ± 0.88	–0.34	0.025	
MMT	Group 1	3.00 ± 0.53	3.93 ± 0.79	+0.93	0.001	0.033
	Group 2	3.00 ± 0.65	3.33 ± 0.61	+0.33	0.025	

Note: SD: Standard Deviation; Group 1: Shoulder Stabilisation Exercise and Sensorimotor; Group 2: Shoulder Stabilisation Exercise only

The normality test was conducted using the Shapiro–Wilk test because the sample size in each group was fewer than 50 subjects. The results showed that the data for both MACS and MMT variables were not normally distributed ($p < 0.05$), indicating that non-parametric tests were required. The Wilcoxon test in each group and measurement obtained $p<0.05$. There was a significant difference after giving interventions in each group as measured by MACS and MMT. The MACS and MMT measurements obtained $p<0.05$ in Mann Whitney U test. There was a significant difference between group 1 and group 2.

Based on the results of data processing, in group 1 with the MACS measurement there was a decrease in score with an average of 1.18 and an increase in MMT with an average of 0.93. Meanwhile in group 2 with a MACS measurement there was a decrease with an average of 0.34 and an increase in MMT with an average of 0.33. This shows that group 1 showed a better difference than group 2.

DISCUSSION

It was shown that the addition of sensorimotor exercises to the shoulder stabilization exercise intervention showed better results than just shoulder stabilization exercises in increasing upper extremity strength and fine motor coordination in the Down syndrome population. This research is strengthened by previous research conducted by (Elserty & Wagdy, 2020) in which shoulder stabilization exercises had a positive effect on grip strength in children with Down syndrome. They further explained that the movement develops from proximal to distal.

If there is a stability problem in the shoulder, it can affect the movement and function of the hand. If the stability of the proximal shoulder is good, it will optimize muscle recruitment in the distal part and improve the function of the hand. Another study about effect of shoulder stability exercise on functional hand grips showed that shoulder stabilization exercise is effective in increasing the stability of the shoulder and functional of the hand. Giving this exercise increases the activation of the upper trapezius, serratus anterior, and lower trapezius muscles which are muscles with a very important role in stabilizing the shoulder (Olczak et al., 2022).

In addition, there is also an increase in hand strength and hand function. Shoulder stability exercises help improve shoulder stability, strengthen shoulder function, and strengthen the stabilizing muscles, which in turn benefit in hand function. This training distributes the workload evenly between the hands, which can further improve grip strength and overall hand function (Yadav & Kanase, 2025).

Several studies have shown that shoulder stabilization exercise can increase the strength and function of the hands. In this study, shoulder stabilization exercise was combined with sensorimotor exercises, and the results were better than just shoulder stabilization exercise. Based on previous research related to sensorimotor exercise and hand and upper extremity function, it showed that the provision of sensorimotor exercises improved sensorimotor function in the upper extremities and hands in patients with Cerebral Palsy (Kleeren et al., 2024).

It was further explained that the provision of tactile sensory stimulation is very important in fine motor development. Sensory stimulation also directly through the mechanism of motor function affects the plasticity of the nerve. In one of the pilot studies on cerebral palsy, patients who were given sensorimotor exercises caused structural changes in sensory and motor areas (Poitras et al., 2021).

Another study showed that sensory integration exercises have a positive effect on attention and motor skills. A child with DS has problems with attention. Lack of attention related to the lack of cognitive ability to receive learning (Raharjo et al., 2023). Sensory integration exercises aim to improve attentional ability, eye and hand coordination, strengthen tactile sensory system, orientation, selective attention, and body awareness. This exercise can help to raise attention and improve motor skills in children with DS (Hartono et al., 2024).

The results of this study have important implications for rehabilitation interventions in children with Down syndrome. A combination of shoulder stabilisation exercises and sensorimotor exercises may be considered a more effective therapeutic option for improving upper extremity strength and fine motor coordination. These findings can also serve as a basis for occupational therapists and physiotherapists to design more comprehensive exercise programmes that take into account proximal stability and sensorimotor integration.

This study has several limitations. First, the sample size was relatively small, so the results should be generalised with caution. Second, the limited duration of the intervention meant that the researchers were unable to assess the long-term effects of the exercises. Third, this study was only conducted in two clinics in the Denpasar and Badung areas, so the diversity of subject characteristics may not have been fully represented.

Further research is recommended using a larger sample size and involving various health care facilities to improve population representativeness. A longer intervention duration and post-intervention follow-up are also recommended to assess the sustainability of the exercise effects. Additionally, the use of more objective assessment instruments, such as motion capture analysis or electromyography, could strengthen findings related to muscle activation and motor function changes.

CONCLUSION

The addition of sensorimotor exercises to the shoulder stabilization exercise intervention showed better results than just shoulder stabilization exercises in increasing upper extremity strength and fine motor coordination in the Down syndrome population. The addition of this exercise can be given to achieve good results in patients with Down

syndrome. This effectiveness demonstrates that sensorimotor stimulus integration can maximise proximal stability, increase muscle activation, and improve the sensorimotor integration process, which plays an important role in hand function. These findings provide a more comprehensive understanding that strengthening shoulder stability needs to be combined with sensorimotor modulation to produce more significant functional changes.

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DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

AI tools were used solely for grammar and language editing. The authors take full responsibility for the content and integrity of the manuscript.

CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

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