# EFFECTS OF TRUNK STABILITY EXERCISES ON HAND FUNCTION IN CHILDREN WITH CEREBRAL PALSY

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## Abstract

**Background:**

Cerebral palsy is a permanent damage in early brain in fetus which leads to movement disorder. The most frequent reason of bodily incapacity is cerebral palsy in pediatric population. CP children have difficulty maintaining dynamic and static trunk stability, which leads to affect sitting, standing, reaching and walking. Hemiplegic Cerebral palsy patients are challenged by fine motor skills, like gripping or object handling, which are essential for activities of daily life.

**Objective:**

To determine the effects of trunk stability exercises on hand function in children with cerebral palsy.

**Methods:**

It was a randomized, clinical trial, conducted among hemiplegic CP patients. Sample size was 26 by using Epitool software. Subjects were randomly allocated to the intervention or control group after a baseline evaluation with a lottery ticket and an opaque envelope. All patients in both groups were assessed on three occasions: (i) baseline (ii) post treatment and (iii) after 4 weeks follow up to assess long term effects. The pre and post assessment was performed after 8 weeks of treatment respectively and long-term assessment was performed after 4 weeks follow with TCMS, CHEQ and ABILHAND-kids measurement scale. Each session of 45 min core stability exercises was performed on subjective sample.

**Results:**

There were statistically significant differences observed for TCMS, CHEQ and ABILHAND-kids measurement scale. ($p < 0.05$) between control and intervention group.There were statistically significant changes ($p < 0.05$) observed in symptoms of with TCMS, CHEQ and ABILHAND-kids measurement scale in both groups.

**Conclusion:**

Recent study concluded that core stability exercises are beneficial for children with hemiplegic CP in improving their hand abilities. Trunk stability exercises are effective treatment for improving the hand function and have a positive long-term effect. These results should be applied in clinical practice by physicians and patients to get good results.

**Key words**: cerebral palsy, gross motor function, hand function, trunk stability.

## Introduction

Cerebral palsy can be described as a permanent damage in early brain in fetus which leads to movement disorder. The most frequent reason of disability is cerebral palsy in pediatric population. This disorder can result from prenatal or postnatal brain damage. Along with movement disorders there is a number of problems we can see like Intelligence, sensation, speech, behavioral and perceptional issues, Other than these motor and sensory impairments epilepsy and relative MSK conditions are also observed in CP (1).

Cerebral palsy is heterogeneous in different clinical types, co comorbidities, different brain imaging patterns and etiology, plus now the background genetic disorders. Few are just due to extreme hypoxic event or decrease in oxygen saturation at the time of birth. CP is more appropriately referred to as "cerebral palsies" because there are several patterns, types and degree of disabilities in the clinical presentation of cerebral palsy. (2).

The average prevalence of cerebral palsy is approximately 1.5 to three per 1000 births. These numbers vary with risk factors in specific patient group, depending on different risk factors.(3) Pregnancy, delivery, continuity and infection are identified as Important risk factors for cerebral palsy (4).There are several barriers that affect practitioner decision making in differential diagnosis of "pattern recognition and confidence in provisional diagnosis (5)

Motor impairment in cerebral palsy are further classified into three sub types, spastic cp is defined as a posture and movement disorder with tone disturbance (6) .Spastic cerebral palsy is the most common presentation, followed by atheist, aphasia, and mixed types in Pakistan (7). 35 percent of children with Cerebral palsy have spastic hemiplegia which is considered the most frequent clinical presentation of CP. Statistic paresis is more affecting lower extremities asymmetrically and is less affecting upper extremities. The effective use of upper limbs, especially the hands, plays an essential role in activities of daily life. Heavy, rhythmic and very precise activities can be performed with hands. (8) . 25% of CP children have hemiplegia. Spastic hemi paresis is common in term infants and most cases are caused by intrauterine or right after birth stroke. Most children with unilateral palsy have normal cognitive ability and can walk independently and maintain a high level of functioning (9).Children with hemiplegic cerebral palsy experience some negative features due to upper motor neuron syndrome. Impaired disorders include decreased strength and sensation in the upper limbs, decreased motor control and increase in spasticity. Because of these disorders, children with hemiplegic CP suffer from severe dysfunction of upper extremities and disability. (10)

Clinicians go for therapeutic interventions to reverse or improve the effects of damage on functional growth as part of a broader therapeutic intervention approach, with the help of International Classification of Functioning, Disability model scale.(11) Anticipatory postural modifications arise from core muscle training, in which position body to endure equilibrium disturbances caused by kicking, propelling, or sprinting power (12).Tran cranial magnetic stimulation is a helpful tool used for examination of functional brain reorganization in subjects with hemiplegic cerebral palsy (HCP) (13).Training of upper extremity with core strengthening supports visual feedback, balance, and arms function. Restraining the entire spine can eliminate unnecessary trunk movements, but it can impede the affected side's movements and prevent the arms from stirring along the scapula and upper trunk. Holding the whole trunk inhibits progress and restricts the upper limbs(14). Most of daily living activities are two-handed work, but the selective activity can differ between high-impact limbs and low-impact limbs. In a developmentally typical child, the prevailing hand is used for precise activities; on the other hand, non-dominant limb is used for stable work (15). For instance, a child grips the pen with his dominant hand and holds the paper with his other hand while writing. Likewise, children with cerebral palsy have a preference to use limbs that have least effect on daily life activities, so it is expected that there will be a difference in functional role between limbs that have a greater effect and those that have less effect. High-impact limbs are not the dominant hand, and low-impact limbs are used as the dominant hand (16) Rehabilitation for patients with cerebral palsy commonly uses a number

of therapeutic exercises, including strengthening, stretching, balance training, and functional task-based training. These exercises are performed mainly on land and they have been shown to progress gross motor activities in patients diagnosed with hemiplegic CP(17)

In particular, retention of the trunks will force individuals while reaching the exercise while not using the abnormal capacity of the arm. In addition, research supporting hypotheses that help training with trunk restraint (TR) helps improve functional skills (18). Trunk stability has a fixed reliability in enhancing core muscle function. Researchers report that the training of core stability can improve not just trunk function; however, equilibrium and mobility, as spine muscles bear the lumbo-pelvic to hip compound. Trunk stability exercises simultaneously activate the abdomen and multifidus muscles to help stabilize the body and head between initial and limb movements (19).Trunk control ability strongly influences functional upper limb movements when assessing upper limb function in such children, it is necessary to assess trunk control ability(20). This relationship between core stability and gross motor function must be considered for effective evaluation and intervention of physiotherapy(21). Postural control and the effectiveness of the center of the body for fine motor handiness are general beliefs. The plan of action is transferred by pyramidal system that originates in the motor parts of the cerebral cortex and controls the complexity of voluntary and multimodal motor movements of the upper limb (22). It is important to incorporate ways to improve hand function. For that reason, the main rationale of this research was to find out the outcome of trunk stabilizing exercises on the fine motor skills of subjects with hemiplegic CP. The significance of this study was to identify how much core stability exercises improved hand function. This study helped in gathering evidence on the practice of core stabilizing exercises to improve hand function so that it can help both physicians and patients.

## MATERIAL AND METHODS

This randomized controlled trial was conducted after the Ethical approval from ethical committee of Riphah International University Lahore. The clinical trial was registered at WHO trail registry with the number NCT05491863. After informed written consent, a total of 26 patients were enrolled in this study and then divided into two groups with 13 patients in each group. Sample size was calculated using Epitool software. Non probability sampling technique was used to collect data from 'Rising Sun Institute for Special Children. Following inclusion Criteria was used:

- Both male and female were included.
- Age group 6 to 18 years.(23)
- Medically diagnosed with hemiplegic cerebral palsy.

- Unilateral Movement deficit (less than 2.5) on amount of use scale on MAL (motor activity log).(24)
- Level 1 to 3 on manual ability classification system (MACS).
- Mild to moderate spasticity of upper extremity (MAS grade 1 to 2.)
- GMCS level I-II.
- Subjects were cognitively capable and competent to follow the instructions(1)

Following Exclusion criteria was used:

- Patients with altered conscious level.
- Previous surgical procedure or pain in upper extremity.
- Rigid contracture and fixed deformities in the spine.
- Auditory / vision problem.
- Previous Botulinum Toxin-A injections in upper limb.
- Cardio-respiratory problem.(25)

**Randomization:**

The randomization was conducted using sealed envelopes by lottery method. Children were randomly assigned to treatment group in a 1:1 ratio.

**Blindness:**

The study was double blinded both participants and the assessor who evaluated the participants was not informed of how the participants were grouped were blinded in this research.

**Data Collection Procedure:**

All participants in both groups were assessed at three different time points: (i) at baseline, (ii) post-intervention, and (iii) after 4-week follow-up. Assessment was conducted in room at facility and included demographic information collection, inclusion criteria screening questionnaire, and scale to assess trunk stability and hand function. (Check out TCMS, ABILHAND-kids and CHEQ).

**Group A (control group)** General stretching was performed for 5 min. Received conservative physiotherapy plan for the affected upper limb: Physiotherapy plan consist of following exercises: ♣ Facilitation of posture. ♣ Proprioceptive facilitation like weight bearing movements for the upper extremity. Sit to stand, standing, holding on to stand, free arms standing up, upholds on standing asked the patient to high one leg, one leg stand-up, standing on the balance board ♣ Straight and sideways parallel bar walk. ♣ For the effected body side jumping on stable and dynamic surface. ♣ Upstairs and

down stair activity performed on staircase. Duration and frequency: 40 minutes with a rest period of two minutes among each group of trainings, 4 days per week for 8 workweeks (32 sessions)(12). Follow up: Hand function and trunk control was assessed at the end of 4 weeks to investigate long term effect of trunk stability exercises.

**Group B (Treatment group)** General stretching was performed for 5 min. Received additional trunk stability exercises along with conservative physiotherapy program for the affected upper limb: Physiotherapy plan consist conservative treatment same as control group with addition of trunk control exercises Trunk stability exercises It included three levels. The complexity of each level varies as it began from performing activities on an even surface to finished with uneven surface (physio ball)

- Proprioception: Supine abdominal draw was performed in 1st simple level ,3 sets per 20 repetitions were performed. A double knee to chest abdominal draw was performed with 3 sets per 20 repetitions. Supine twist with 3 sets per 20 repetitions was performed.
- Balance: Pelvic bridging was 2nd complicated level performed as 3 sets with 4-6 repetitions. Pelvic Twists using a medicine ball were performed as 3 sets with 10–20 repetitions.
- Stability: Supine bridging with head lied on physio ball was performed in 3rd difficult level when holding the position for 4 to 6 seconds, then relaxed slowly for same time as 3 sets per 10 to 20 repetitions. Bridging in prone lying was performed with 3 sets per 4 to 6 repetitions. There was a 30 seconds to 1 minute break between the sets
- Duration and frequency:1 hour with a rest duration of 2 minutes among every exercise group, 4 days per week for 8 weeks (32 sessions) Follow up: Hand function and trunk control exercises were assessed at the end of 4 weeks to investigate long term effects of trunk stability exercises.(12)

**Ethical Consideration:**

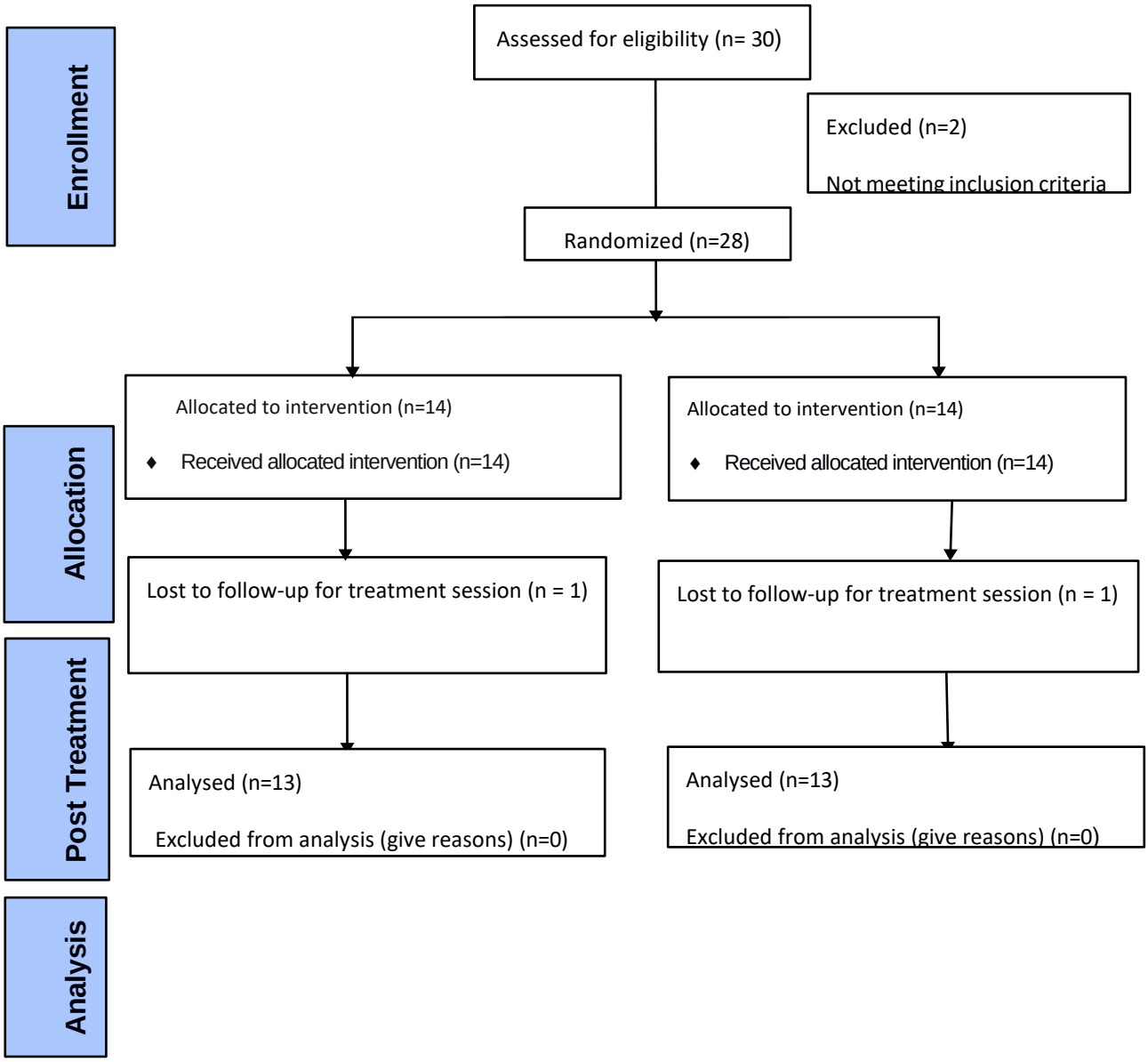
- Ethical approval was obtained from the Ethical committee of Riphah International University, Lahore.
- Informed consent was taken from the participants and confidentiality was assured to the patients.
- All the information was provided to the patient that what will be potential benefits of the treatment and without any harm.

**DATA ANALYSIS**

The collected data was entered and analyzed by SPSS 25 version. For qualitative variables like gender, socioeconomic status, family history and hand function, the frequency with percentages was calculated. For quantitative variables like age, TCMS, CHEQ and ABILHAND-kids questionnaire

the mean with standard deviation was calculated before and after treatment and after 4 weeks follow up. Normality of data was checked with Shapirowalk test and Mix Model An-ova test was applied for the contrast of results within and between groups. P value ($p < 0.05$) was taken as significant.

**Flow diagram for study data collection procedure (According to CONSORT guidelines)**



## Results

In current study 26 patients were enrolled, 13 in each group. All the data at baseline in this study was normal in distribution. So, parametric statistics for the analysis of data of both the groups are used in current study. The mean age of participants in Group A and group B was as (11.31±2.95 vs. 11.38±1.50 years). In group A 61.5% were male and in Group B 76.9% patients were male. In group A 38.5% patients and in B 46.2% patients has lower socioeconomic status. In group A 6(46.2%) patients had family history and in group B 3(23.1%) patients had family history. In group A 7(53.8%) patients had right hand/arm reduced function & 6(46.2%) patients had left hand/arm reduced function and in Group B 9(69.2%) patients had right hand/arm reduced function & 4(30.8%) patients had left hand/arm reduced function with p value (p=0.420). The results of TCMS Scale score were showed as in Group A and B at baseline was as (30.15±3.34 vs. 30.77±4.32, p=0.688), after intervention was (33.23±4.27 vs. 41.46±5.14, p=0.0001) and at 4 weeks follow up was (34.15±4.26 vs. 44.23±4.38, p=0.0001). The results of ABILHAND-Kids Scale were showed as in Group A and B at baseline was as (34.38±3.77 vs. 34.61±3.43, p=0.872), after intervention was (35.77±3.83 vs. 39.85±3.08, p=0.006) and at 4 weeks follow up was (36.92±3.38 vs. 41.85±3.51, p=0.001). The results of CHEQ Scale found that the grasp efficacy in Group A and B at baseline was as (41.00±10.10 vs. 44.69±10.07, p=0.360), after intervention was (42.62±11.03 vs. 55.77±7.28, p=0.001) and at 4 weeks follow up was (44.00±10.85 vs. 57.00±6.79, p=0.001). In current study all the tools showed improvement in scores after core stability exercises in hand function of Cerebral palsy patients. There were statistically significant differences observed for CHEQ Scale, TCMS Score, ABILHAND Kids Scale and hand used ($p < 0.05$) between control and intervention group. Statistically substantial changes ($p < 0.05$) were perceived in symptoms of CHEQ Scale, TCMS Score, ABILHAND Kids Scale and hand used in both groups

**CHEQ Scale between groups (Independent sample t-test)**

| Variables | | Control Group | Intervention Group | p value (between group) |
|---|---|---|---|---|
| Grasp efficacy | Baseline | 41.00±10.10 | 44.69±10.07 | 0.360 |
| | After intervention | 42.62±11.03 | 55.77±7.28 | 0.001* |
| | 4 weeks follow-up | 44.00±10.85 | 57.00±6.79 | 0.001* |
| Time utilization | Baseline | 42.15±10.26 | 34.08±7.44 | 0.031* |
| | After intervention | 44.23±10.19 | 52.54±11.98 | 0.069 |
| | 4 weeks follow-up | 44.69±10.26 | 53.08±11.24 | 0.058 |
| Feeling bothered | Baseline | 40.15±15.51 | 29.08±6.90 | 0.027* |
| | After intervention | 43.38±13.71 | 37.85±9.55 | 0.244 |
| | 4 weeks follow-up | 44.77±14.21 | 40.46±8.67 | 0.360 |
| One hand use | Baseline | 5.38±1.85 | 5.92±1.38 | 0.409 |
| | After intervention | 6.38±2.02 | 8.38±1.04 | 0.004* |
| | 4 weeks follow-up | 6.77±2.17 | 9.54±1.13 | 0.0001* |
| Both hand use | Baseline | 5.31±1.38 | 7.92±1.85 | 0.0001* |
| | After intervention | 5.77±1.01 | 9.46±1.05 | 0.0001* |
| | 4 weeks follow-up | 6.15±1.21 | 10.23±1.42 | 0.0001* |

**TCMS Score between groups (Independent sample t-test)**

| Variables | | Control Group | Intervention Group | p value (between group) |
|---|---|---|---|---|
| **TCMS Score** | Baseline | 30.15±3.34 | 30.77±4.32 | 0.688 |
| | After intervention | 33.23±4.27 | 41.46±5.14 | 0.0001* |
| | 4 weeks follow-up | 34.15±4.26 | 44.23±4.38 | 0.0001* |

**ABILHAND-Kids Scale between groups (Independent sample t-test0**

| Variables | | Control Group | Intervention Group | p value (between group) |
|---|---|---|---|---|
| **ABILHAND-Kids Scale** | Baseline | 34.38±3.77 | 34.61±3.43 | 0.872 |
| | After intervention | 35.77±3.83 | 39.85±3.08 | 0.006* |
| | 4 weeks follow-up | 36.92±3.38 | 41.85±3.51 | 0.001* |

**CHEQ Scale within and between groups (Mix Model ANOVA)**

| Variables | | Control Group | Intervention Group | p value (Within group) |
|---|---|---|---|---|
| Grasp efficacy | Baseline | 41.00±10.10 | 44.69±10.07 | 0.0001* |
| | After intervention | 42.62±11.03 | 55.77±7.28 | |
| | 4 weeks follow-up | 44.00±10.85 | 57.00±6.79 | |
| Time utilization | Baseline | 42.15±10.26 | 34.08±7.44 | 0.0001* |
| | After intervention | 44.23±10.19 | 52.54±11.98 | |
| | 4 weeks follow-up | 44.69±10.26 | 53.08±11.24 | |
| Feeling bothered | Baseline | 40.15±15.51 | 29.08±6.90 | 0.020* |
| | After intervention | 43.38±13.71 | 37.85±9.55 | |

| | | | | |
|---|---|---|---|---|
| | 4 weeks follow-up | 44.77±14.21 | 40.46±8.67 | |
| One hand use | Baseline | 5.38±1.85 | 5.92±1.38 | 0.0001* |
| | After intervention | 6.38±2.02 | 8.38±1.04 | |
| | 4 weeks follow-up | 6.77±2.17 | 9.54±1.13 | |
| Both hand use | Baseline | 5.31±1.38 | 7.92±1.85 | 0.0001* |
| | After intervention | 5.77±1.01 | 9.46±1.05 | |
| | 4 weeks follow-up | 6.15±1.21 | 10.23±1.42 | |
| | **Baseline** | 16.31±2.32 | 13.15±1.72 | |
| | **After intervention** | 14.85±2.67 | 9.15±1.21 | |
| | **4 weeks follow-up** | 14.15±2.91 | 7.23±1.69 | |

**ABILHAND-Kids Scale within and between groups (Mix Model ANOVA)**

| **Variables** | | **Control Group** | **Intervention Group** | **p value (Within group)** |
|---|---|---|---|---|
| **ABILHAND-Kids Scale** | Baseline | 34.38±3.77 | 34.61±3.43 | 0.0001* |
| | After intervention | 35.77±3.83 | 39.85±3.08 | |
| | 4 weeks follow-up | 36.92±3.38 | 41.85±3.51 | |

**TCMS Score within and between groups (Mix Model ANOVA)**

| **Variables** | | **Control Group** | **Intervention Group** | **p value (Within group)** |
|---|---|---|---|---|
| **TCMS Score** | Baseline | 30.15±3.34 | 30.77±4.32 | 0.0001* |
| | After intervention | 33.23±4.27 | 41.46±5.14 | |
| | 4 weeks follow-up | 34.15±4.26 | 44.23±4.38 | |

## Discussion

Upper limb disability affects children with the hemiplegic cerebral palsy (CP), which might affect their ability to execute and engage in everyday activities. Spasticity, decreased strength, and diminished feeling all contribute to this disability. The capacity to regulate the posture and movement of middle section of body is referred to as "core stability". The deep abdominal muscles that link to shoulders, hip and spine to keep proper posture and provide a establishment for limbs activity that are targeted with core exercises (26)

The core muscles are required for enough endurance, power and strength in order to produce optimal spinal stability. Balance, endurance, strength, and associated pelvic, abdominal and back muscular actions are all part of core stability. The motor function of upper extremities was significantly impaired in hemiplegic CP children. Cerebral palsy patients often have difficulty reaching, grasping, moving, releasing, and manipulating items, all of which are critical for quality and execution of everyday activities.(27)

It is important to practice techniques to maximize hand function. For that reason, the purpose of present research is to evaluate the outcome of trunk stabilizing exercises on the fine motor skills of patients with hemiplegic CP. It's critical to include techniques that optimize the use of damaged limb. Therefore, this study was conducted at "Rising Sun Institute for Special Children Lahore" to investigate the effects of trunk stabilizing exercises on the fine and overall hand motor skills of hemiplegic cerebral palsy patients. 26 hemiplegic patients with age group 6 to 18 years were enrolled after meeting inclusion and exclusion criteria then randomly divided in two equal groups.

11.35 was mean age of patients with standard deviation 2.297. In group A 61.5% patients were male & 38.5% patients were female and in Group B 76.9% patients were male & 23.1% patients were female. In current study all the tools (CHEQ Score, TCMS Score and ABILHAND Kids Scale) were showed improvement in scores after core stability exercises in hand function of Cerebral palsy patients. Relatively smaller improvement was observed in long term follow assessment as well.

It's difficult to compare results of current study with previous studies because limited literature was found for specifically hemiplegic cerebral palsy patients, investigating

particular outcome of trunk stability exercises on hand function. However, similar research by Abd-Elfattah et al was found. They looked at how trunk stability exercises affected arms function in the children with hemiplegic cerebral palsy. In their research, 52 children were included. They were split into two groups (control and study) at random. Study group underwent the identical physiotherapy exercise regimen as control group, as well as core stability exercises.

To evaluate the efficiency of functional core strengthening for trunk stability plus upper extremity function in patients with autosomal recessive hereditary ataxia, a research was conducted in 2022. 20 patients were randomized into experiment and control group. Core stabilization and balance training exercise was received by both groups but the experimental group received additional core functioning .they concluded that additional core stability exercise may improve upper limb function in patients with ataxia (22). These results matched with current study but the patient's population, age group and assessment tools were different.

In 22 Numan Buluta et al. from turkey suggested that there is a possible relationship between trunk firmness and upper limb performance. They performed an experimental study on Duchenne muscular dystrophy patients to investigate relationship between core strengthening and fine motor skills (28). Results of this study were linked with finding of current study but population was different.in both studies a relationship between core muscles and hand function was similar.

In 2018 a study showed the connection between trunk control and comprehensive upper limb dysfunction in MS patient. They concluded that patients with MS had limited upper arms movement, reduced core stability control, and a prominent association between them, even with RRMS and moderate illness. Identifying core deregulation provides better insights into dexterity problems in MS patients and enables more neurorehabilitation with a focus on the

upper limb .This is in line with research that discovered a substantial link between trunk control and upper limb movement, with better upper limb movement being linked to better stability and trunk control(25).current study results associates with the previous studies in term of trunk control and upper limb link but sample and age group was different.

To evaluate the effects of fine motor exercises on trunk stability, Dr. Poonam H. Patil conducted a

study in 2010. Pre and post assessment was taken from 21 patients with age group 6 to 12 years according to GMFCS, Manual Ability Classification System and TCMS pre and post six weeks of intervention respectively. significant effect of fine motor exercises on trunk stability was found in cerebral palsy patients (1).In this study there was positive intervention effect found that showed a concerned link between hand function and trunk control that resembles with current study.

In female athletes external and internal sensory contribution that involves a critical role in movement therapy, could be responsible for significant improvement in hand skills described in research by Jatin P. Ambegaonkar et al. It's also due to anticipatory postural changes made by core stability workouts, which provide proximal support for distal movement. trunk muscles aid in the stability and movement of body parts, keeping balance and enhancing upper and lower extremity mobility opposing gravity, allowing the limbs to work more efficiently (29).These studies shows relationship with results of current study.

A study conducted by Miyake Y et al on 40 healthy students to evaluate impact of core exercises on upper limb function in relation to motor behavior and postural swing. Concluded that improved proximal stability improves distal mobility; therefore, core workouts increase trunk control to improve arms performance. Core workouts increased upper limb function and postural sway in relation to skillful motor control (8). Another study conducted by Kumaresan A et al. showed that combining core workouts with standard therapies in hemiplegic individuals may improve upper extremity function along with core stability (30). These results relate with current study results regarding importance of core muscle activation and its effect on hand function.

Another study was conducted by El-Nashar et al., which found that trunk muscle activity have no discernible impact on improving upper extremity as compared to traditional physiotherapy, 30 patients with hemiparesis, with age group 45 and 60 years were assigned in two equal groups, study found that core muscle activity had no discernible impact on improving upper limb function when compared to traditional physical therapy using wolf motor function test, trunk impairment scale, and shoulder range of motion(19). But this study contradicts the present research as in current study evidence of a statistical difference found within and between groups, however the population and assessment tools were different. This discrepancy in findings might be attributed to inadequate exercise time.

## CONCLUSION

The findings showed that core stability exercises are beneficial for patients with hemiplegic CP in improving their hand abilities. So, current study concluded that trunk stability exercises are effective treatment that can better the hand function of hemiplegic cerebral palsy patients and have a positive long-term effect. These results should be applied in clinical practice by physicians and patients to get good results using trunk stability exercises.

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