""EFFECT OF TACTILE AND KINAESTHETIC STIMULATION ON NEURODEVELOPMENT AND GROWTH OF PRETERM INFANTS BORN AT <34 WEEKS GESTATIONAL AGE - RANDOMISED CONTROLLED TRIAL STUDY"

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ii

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16

LIST OF ABBREVIATIONS

WHO	World Health Organisation
NICU	Neonatal Intensive Care Unit
SGA	Small for gestational age
PMA	Post Menstrual Age
GA	Gestational Age
CRIB	Clinical Risk Index for Babies
NAPI	Neurobehavioral Assessment of the Preterm Infant
NMBA	Neuromotor Behavioural Assessment
NBAS	Neonatal Behavioural Assessment Scale
HNNE	Hammersmith Neonatal Neurological Examination
HINE	Hammersmith Infant Neurological Examination
WHA	World Health Assembly
ICD	International Classification of Diseases
LMP	Last Menstrual Period
ART	Assisted Reproduction Technology
PPROM	Premature Rupture of Membranes
SRS	Sample Registration System
RGI	Bulletin of Registrar General of India
IMR	Infant Mortality Rate
ASIRs	Age-standardized incidence rates
ASMRs	Age-standardized mortality rates
ENND	Early Neonatal Death
LNND	Late Neonatal Death
PNND	Post Neonatal Death
NFHS	National Family Health Survey
IHD	Ischeamic Heart Diseases
CHF	Congestive Heart Failure
POG	Period of Gestation
EI	Early Intervention

IPAT	Infant Positioning Assessment Tool
NSCS	Neonatal Skin Condition Score
NSRAS	Neonatal Skin Risk Assessment Score
STAITs	State-Trait Anxiety Inventory scores
EFA	Essential Fatty Acid
IGF	Insulin like Growth Factor
OFC	Occipital Frontal Circumference

ABSTRACT

"Effect of tactile and kinaesthetic stimulation on neurodevelopment and growth of preterm infants born at <34 weeks gestational age - Randomised Controlled Trial Study"

Background and Objectives

Preterm very low birth weight infants are at high risk of developing neurodevelopment delay despite of little or no medical complications at the time of birth. The care and intervention of such infants have an impact on pre existing risk. Preterm infants are at risk of growth restrictions, neuroco-gnitive delays or anomalies, various metabolic difficulties, respiratory dysfunction, and ophthalmological and hearing problems. This study evaluates for effect of tactile and kinaesthetic stimulation on neurodevelopment and growth of preterm infants born at <34 weeks gestational age.

Material and Methods

In this randomised controlled trial 60 preterm infants born at <34 weeks of gestation who are haemodynamically stable and ready for discharge were included as a part of the research study.

Enrolled neonates were randomised in 1:1 ratio to one of the following two study groups: therapeutic massage supplementation (intervention group) or control group. Mothers in intervention group were taught about therapeutic massage which consisted of 15 mins each session, twice a day which included tactile and kinaesthetic. Intervention was started at the time of discharge from NICU and continued until 6 weeks or corrected gestational age of 40 weeks whichever is later. At follow up neonates were evaluated at 40 weeks and 3 months of corrected age for their neurodevelopment outcome using HNNE (Hammersmith Neonatal Neurological

Examination) and HINE (Hammersmith Infant Neurological Examination) scales respectively and growth. Results

Out of the 60 preterm infants born enrolled it was found that neonates in intervention group showed higher HNNE as well as HINE scores when compared with the control groups at corrected gestational age of 40 weeks and 3 months respectively. Mean HNNE score was 28 ± 2.52 for control group while it was 30.1 ± 2.83 for the intervention group, there was statistically significant difference between the two groups. Mean HINE score at corrected gestational age of 3 months was 59.93 ± 6.67 for control group while it was 67 ± 6.73 for the intervention group, difference was statistically significant between the two groups. Higher scores indicates better neurological performance.

The mean length of infants at corrected gestational age of 3 months for the control group was (53.72 ± 2.89) cm while for the intervention group it was (55.33 ± 2.85) cm, significant difference in the distribution of length over timepoints in both groups was observed.

The mean OFC at corrected gestational age of 3 months for the control group was (37.84 ± 1.46) cm while for the intervention group it was (38.67 ± 1.36) cm. This concluded that there is significant difference in the distribution of OFC over groups at 3rd month as well as in the distribution of OFC over timepoints in both groups. The mean weight at corrected gestational age of 3 months for the control group was (4586.67 ± 711.48) g while for the intervention group it was (4808.67 ± 710.98) g. It was observed that, there is no significant difference in the mean weight over groups at birth, discharge and 40 weeks and at 3rd month of CGA. However there was significant difference in the distribution of weight over timepoints in both groups.

Conclusion

Therapeutic massage intervention in the form of tactile and kinaesthetic stimulation by the mothers at home in early preterm infants, born at <34 weeks POG , can have an positive impact on neurodevelopment and growth in future. By doing HNNE and HINE, the optimal score obtained for HINE and HNNE showed a significant difference between 2 groups indicating therapeutic massage can help in better neurodevelopment outcome in the infant. It is possible to train and involve mother to provide this therapeutic intervention at home efficiently.

Key Words - Preterm, Neurodevelopment, Tactile and Kinaesthetic Stimulation, Early intervention

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

In India, out of the 27 million babies born every year (2010 data), 3.5 million babies are born premature, that constitutes approximately 13% of all the births.[2]

The incidence for preterm births is increasing and it causes significant challenges for the healthcare structure, especially in an underdeveloped or developing nations.

It has medical, social and economic implications for the families, society and the nation as well.[2]

The morbidity associated with the preterm birth often extends to later life, resulting in physical, psychological and economic stress to the individual as well as the family.

Preterm very low birth weight infants are at high risk of developing neurodevelopment delay despite of little or no medical complications at the time of birth. The care and intervention of such infants have an impact on pre existing risk.

Even if a preterm newborn survives, their poor growth puts them at risk for grownup. They will have growth restrictions, neuroco-gnitive delays or anomalies, various metabolic difficulties, respiratory dysfunction, and ophthalmological and hearing problems.

Poor or restricted growth of infants during early infancy puts such babies at grater risk of developing chronic diseases later in life, for example, diabetes, and myocardial infarction. Thus it add to increasing further problems and stress for the economies around the world.

Infant massage in an ancient therapeutic technique which has been used around the world from centuries. For the infants who undergo or experience painful procedures are exposed to stressful NICU environment, and are separated from parents, from the mother, infant massage has been promoted as method to reduce stress and promote bonding between the mother and the baby.

The manual application of a specific technique to every area of the body, from head to toe, is what is referred to as a massage intervention. This is commonly conducted by the mother's hands. This massage intervention technique employs a methodical external application that is pre-structured, including caressing, stroking, stretching, compressing, and active or passive extension and flexion maneuvers that are within the normal limits of physiological motion.[12]

There is evidence that therapeutic massage has beneficial effects on preterm infants in NICU, including shorter NICU/Hospital stay, reduced pain, improved weight gain, feeding tolerance and neurodevelopment.

Parents who perform massage with their infants also reported experiencing less stress, anxiety and depression.

Preterm neonates who are admitted to neonatal critical care units are deprived of the sensory stimulation from the maternal amniotic fluid and the uterus walls by the skin. Sensations are important and involved in the proper growth of term and mature infants.

Neonatal massage is a calming and soothing touch that promotes healthy growth in premature and low birth infants.

Somatic stimulation, which uses a variety of modalities to excite the sensory receptors that cover the skin surface, muscles, bones, and joints, is the technique that is most frequently used with premature neonates.

The enrichment of preterm infants' social, emotional, and neuromotor development is correlated with tactile and kinaesthetic stimulation.[5-7]

Two component of this intervention, that is, Tactile and Kinaesthetic stimulation, each has its own advantages.

Whereas tactile stimulation leads to increased vagal activity, kinaesthetic stimulation leads to increased calorie consumption.

Tactile and kinaesthetic stimulation helps to lead to improved weight gain, improved sleep awake pattern, better gastric motility, improved somatic and bone growth, improved orientation, spectrum of state, modulation of state, and autonomic stability.[5-9]

Studies regarding the impact of preterm infant massage in NICU settings on growth ie anthropometric measures like weight, length, head circumference and neurological outcomes have been conducted and showed positive effects how ever there is substantially very limited data on effect of the interventional massage, especially by the mothers, on preterm infants in NICU.

For a long time, correction of gestation age was used to evaluate preterm infants' neurodevelopment in the same fashion that gain in weight and height was evaluated. Prematurity isn't the sole risk contributing factor to a delay in infants' acquisition of motor control, according to recent scientific research in this field, as other factors such as maternal practises, environmental elements, and antenatal, natal, and post - natal care health complications are also significant cofact-ors that influence both short- and long-term outcomes.[11]

Preterm babies exhibit an inconsistent developmental pattern which may not necessarily be delayed, when compared to children delivered at term.

In the last 3 decades many methods have been developed for evaluation of the neurologic state of the newborn infant and certainly each has contributed to a better understanding of the neurologic status in infants.

Test of infant motor performance , Clinical Risk Index for Babies-77 (CRIB-II),Neurobehavioral Assessment of the Preterm Infant (NAPI), Dubowitz Neurological Assessment of the Preterm and Full-term Infant (Dubowitz), Neuromotor Behavioural Assessment (NMBA), and the Brazelton Neonatal Behavioural Assessment Scale (NBAS) are a few developmental assessment tools used in previous studies to assess postural and selective control of movement needed for functional motor performance in infant and infants' gross motor development including actions such as posture , weight bearing , and defying gravity movements.

We have used Hammersmith Neonatal Neurological Examination (HNNE) and Hammersmith Infant Neurological Examination (HINE) scoring in our study.

The HNNE and HINE both can be reliably used to assess infants at neurological risk, both preterm and term born. The use of the HINE optimality score and cut off scores provides us the prognostic information on the severity of motor outcome in future. It can further also help to identify those infants needing specific rehabilitation programs.[13]

The Hammersmith Neonatal Neurological Examination (HNNE) is a quick, practical and easy to perform examination tool but to an extent it requires some learning and experience to perform well. There are thirty-four items in the HNNE assessing tone, motor patterns, observation of spontaneous movements, reflexes, visual and auditory attention and behaviour.

The Hammersmith Infant Neuro-logical Examination (HINE) is an uncomplicated and gradable procedure for assessing infants between the years of 2 and 24 months. It consists of 26 items that evaluate several neurological examination components, namely cranial nerves, posture, movement, tone, and reflexes. The HINE takes between 5 and 10 minutes to complete, is simple for using, and is available to all doctors. Even with inexperienced staff, a good cross reliability has been documented. It doesn't have associated costs such as lengthy certifications or proprietary forms.

By doing HNNE and HINE scoring we'll be able detect risk of delayed cognitive performance it also helps in easy identification of risk of delayed cognitive performance in preterm as well as term infants.

The preponderance of these research has been performed on term babies. Studies have been carried out to determine the potential benefits of massage intervention on hospitalised preterm infants, but then again the evidence from these studies has been too weak to directly support massage intervention by mother in the NICU.

Massage therapy, on the contrary, can be utilised as a non-intrusive and simple to learn approach that enhances the bonding between mothers and their newborns, eliminates stress and anxiety in moms, particularly primigravida, and improves their overall health and wellbeing.[3]

Massage is safe and cost effective NICU intervention that boosted preterm neonates' growth and developmental capabilities while showing no negative consequences.

Another major aspect involves using appropriate techniques and methods and optimum culmination of mothers' massage intervention.

This study is intended at providing understanding on the possible consequences of tactile and kinaesthetic massage therapy for premature preterm infants delivered by their mother on neurodevelopment and growth.

Additionally this study will also provide us evidence to include mother in infant massage intervention and implement in on regular basis for preterm infants. Additionally, it will enable us to offer suggestions for mothers' ideal massage intervention.

OBJECTIVES

Primary -

- To assess neuro-developmental outcome of preterm infants born at <34 weeks of gestational age, who have received tactile and kinaesthetic stimulation.

Secondary -

- To study the effect of tactile and kinaesthetic stimulation by the mothers on the growth, that is, anthropometric parameters of stable preterm infants born at <34 weeks of gestational age.

- To assess if tactile and kinaesthetic stimulation of the baby decreases maternal anxiety and stress while caring for the infant at home.

REVIEW OF LITERATURE

According to WHO every year, an estimated 15 million babies are born preterm (before 37 completed weeks of gestation), and this number is rising.[2]

Prematurity was initially defined based on birth weight, using a categorization of less than 2300 or 2500 g. The World Health Assembly (WHA) first proposed a working definition in 1948, employing a threshold of 2500 g (5 pounds, 8 ounces) or less as a determinant.

Preterm birth is defined by the International Classification of Diseases (ICD-9, ICD-10) as occuring after a period of gestation of less than 37 full weeks (or 259 days). The very first day of the LMP is used to calculate the gestational period. GA is measured in days or weeks that have been completed.[18]

Where the date of the LMP is not available, Fundal height in association with more accurate assessment tools is often used especially in low resource settings.

Due to the advent of Ultrasonography, and use of home pregnancy test-kits, artificial reproductive techniques etc actual timing of conception can be easily determined and therefore accurate dating of gestational age can be performed. Pregnancies achieved through Assisted reproductive techniques represent the most accurate method.

The Ballard Maturational Score, popularly known as the New Ballard Score, has been improved and expanded to include extremely preterm neonates and is described as a precise and reliable prenatal evaluation tool. It is based on a physical and neurological assessment of the neonate.

The most frequently used and recognised definition of preterm birth is still that offered by the World Health Organization (WHO).[2]

Preterm can be defined as babies born alive before 37 weeks of pregnancy are completed. There are sub-categories of preterm birth, based on gestational age:

- extremely preterm (less than twenty eight weeks)
- very preterm (twenty eight to thirty two weeks)
- moderate to late preterm (thirty two to thirty seven weeks).

Approximately 15 million babies are born premature every year, that is more than 1 in every 10 babies. Approximately 1 million children die each year due to complications of preterm birth. Many preterm neonates who survive face a lifetime of near cognitive disability, and issues with hearing and vision.[2]

Prematurity is the leading cause of mortality for children under the age of five worldwide. Preterm birth is an issue that impacts the entire world, although more than 60% of preterm births take place in Africa and South Asia.

Predisposing maternal, foetal, and placental variables have been identified as significant causes of preterm delivery. Because the causes of preterm birth are extensive, it is challenging to pinpoint the pathophysiology that commences preterm birth. The most prevalent of them are antepartum haemorrhage or abruption, hormonal changes, bacterial infection, and inflammation, aside from mechanical factors such uterine over-distention and cervical incompetence.[2,23]

During last two decades introduction of ART (assisted reproduction technology) has caused increase in number of multiple birth thereby indirectly there has been increase in number of preterm deliveries.[21]

Multiple pregnancies increase a female's risk of preterm birth, which might result from spontaneous labour, premature rupture of such membranes (PPROM), pre-eclampsia in the woman, or congenital abnormalities.

Certain epidemiological studies have identified risk factors for preterm births

- maternal age of <17 years or more than 35 years
- mother being underweight
- mother having an overweight pre pregnancy BMI, and short stature

Preterm birth rates vary geographically and within certain ethnic origins, with low and middle income nations consistently having higher rates. Physical and psychosocial stress and smoking have also been associated with higher preterm risk as does a previous preterm birth.

WHO had released a report in 2012 *Born too soon:* the first-ever estimates of preterm birth by nation from the *global action report* on preterm delivery.[17]

Top 5 countries with the greatest no. of preterm births -

India: 3,519,100

China: 1,172,300

Nigeria: 773,600

Pakistan: 748,100

Indonesia: 675,700

Top 5 countries with highest rates of preterm birth/100 live births -

Malawi: 18.1 preterm births per 100 births Comoros: 16.7

Congo: 16.7

Zimbabwe: 16.6

Equatorial Guinea: 16.5

As per the Sample Registration System (SRS) Bulletin of Registrar General of India (RGI), the Infant Mortality Rate (IMR) has lowered at the national level from 37/1000 live births in 2015 to 30/1,000 live births in 2019.

Table 1

The details of Infant Mortality Rate (IMR) for the period from 2015 to 2019 are as follows:

	2015	2016	2017	2018	2019
India	37	34	33	32	30

Age-standardized incidence rates (ASIRs) and age-standardized mortality rates (ASMRs) of neonatal preterm birth decreased overall from 1990 to 2019 according to a cross-sectional study by Cao G, Liu J, Liu M. Global et al. using data from the Global Burden of Disease study; however, ASIRs and ASMRs increased in some regions with high sociodemographic index regions and in Southern Sub-Saharan Africa.[22]

However number of newborn preterm births that occurred incidentally fell globally from 16.06 million in 1990 to 15.22 million in 2019, while the number of deaths decreased from 1.27 million in 1990 to 0.66 million in 2019.

Preterm delivery, however, continues to be a major burden for children internationally, with an increase in ASIR in high-SDI regions and in ASMR in Southern Sub-Saharan Africa between 1990 and 2019. Consequently, it becomes imperative to put forth efforts to lessen preterm birth incidence and deaths.[22]

In south Asia (PURPOSe): a prospective cohort study was carried out between July 1, 2018, and March 26, 2020, to find causes of death in preterm neonates and of the 3470 preterm neonates enrolled, 804 (23%) died by 28 days after birth, and it was found that intrauterine hypoxia and congenital infections were the major causes of neonatal death among preterm babies. Maternal hypertensive disorders and placental disorders, especially maternal and foetal vascular malperfusion and placental abruption, substantially contributed to these deaths.[24]

Y.V., Patel, Pusdekar, A.B, Kurhe, K.G et al. carried out another study that examined the prevalence and risk factors for preterm delivery and low birthweight in six low- and low-middle income nations.

In their investigation, Pusdekar & al. included a record of 272,192 live births. Preterm birth rates ranged from 8.6% in Belagavi, India, to 21.8% in Pakistan, with a median of 12.6%. With a range of 2.7% in Kenya to 21.4% in Pakistan, the overall low - birth - weight rate was 13.6%.

Preterm birth and low - birth - weight rates combined were 5.5% overall (spanning from 1.2% in Kenya to 11.0% in Pakistan).

It was observed that preterm and LBW neonates were born particularly among young, especially less than 20 years, women who are nulliparous and have only had minimal antenatal care resulting in devere antenatal haemorrhage, and hypertensive disease.[25]

In a study done by Ajit Kumar Kannaujiya , Kaushalendra Kumar et al to study the effects of preterm birth on early neonatal, late neonatal, and postneonatal mortality in India ,this study establishes the association of preterm birth and ENND, LNND, and PNND using the reproductive calendar canvassed as part of NFHS-4. This study concluded that children who were born preterm were four times more likely to die in the early neonatal or late neonatal periods, and more than 1.7 times more likely to die in the postneonatal period.[26]

A study was conducted to determine the long-term effects of prematurity by Merline Benny and Cristina I. Pravia from University of Miami Miller School of Medicine, Miami, FL.

With more premature babies being born and more of them surviving, practitioners should be aware of their patients' birth track records and regarding the potential long-term effects of prematurity.

This is since premature infants have a much higher likelihood of acquiring chronic breathing problems, cardiac, renal, and endocrine system ailments later in life. Such knowledge may assist with early disease detection and concentrated lifestyle choices.

A theory known as "developmental programming" or the Barker hypothesis suggests that early prenatal and postnatal exposures may have lifelong health ramifications and that researchers have reviewed may increase short-term survival.[27]

Premature babies are born before major organ development is finished, so such neonates may have later negative health effects related to organs failing to achieve optimal development or undergoing more sharp decline. The 3rd trimester of pregnancy, i.e. > 28 weeks, is a period of rapid organ maturation and growth.

Along with specific organ vulnerabilities, oxidative stress spurred on by the changed environment at birth can shorten telomeres and induce DNA methylation, which culminates in epigenetic changes that appear later in life. Because these newborns must make an early transition to the outside world, the hypothalamic-pituitary-adrenal axis is overstimulated.

Preterm delivery was linked to higher mortality in early childhood (ages 1–5), young adulthood (ages 18–36), and even in those born late preterm, that is, between 34 and 36 weeks, who lived to 1 yr, according to a 2011 Swedish national cohort study of adults born between 1973 and 1979.

In a follow-up study which included births through 1997, the prevalence of survival without any substantial comorbidities at ages 18 to 43 years was 55% in preterm infants (22% of those who were born extremely preterm, 49% of those who were born very preterm, and 58% of those who were born late preterm), roughly equivalent to 63% in full-term infants.[28,29]

Table 2

Summary - Studies done to evaluate long term impact of early birth on distinct organ systems in childhood and possible interventions

Organ system Involved	Problem	Interventions
Pulmonary[30-33]	Pulmonary hypertension andiseasesd obstructive	Review past asthma diagnoses and factor in pulmonary function testing at baseline Lifestyle changes Flu and *Pneumococcal* vaccinations
Renal[36-40]	Chronic Renal Disease	Periodic assessment of BP Keep nephrotoxins at bay Limit salt intake Consider about performing periodic renal ultrasounds and urine microalbumin examinations.
CNS[51-53]	Autism, Mood disorders, Cerebral Palsy , Intellectual disabilities	Be alert for early evaluation and support
Cardio vascular[41-47]	Hypertension, IHD, CHF, peripheral vascular disease	Monitor blood pressure regularly, Lifestyle modifications Consider baseline 2D echo with appropriate cardiovascular risk assessment
Endocrine[52,54-57]	Diabetes, metabolic syndrome, obesity,	Monitor blood glucose, body mass composition, lipids Lifestyle modifications Calcium and vitamin D supplements as needed. Encourage weight-bearing activities Limit prescription drugs that may aggravate dyslipidemia, metabolic disorders, or bone density.

Premature neonates have impaired vascular and alveolar development with increased asthma risk, poorer lung function in future. Long-term results are boosted by lung injury countermeasures, such as noninvasive ventilation. However, abnormal lung vascularization driven on by premature delivery has a detrimental effect on the growth of the lung's vascular system in the future and may put stress on the heart, contributing to right ventricular dysfunction and pulmonary artery hypertension in later life.[30,31,34]

In the 1st sec of expiration, Kotecha et al. discovered a deficiency of 7.2% in anticipated forced expiratory volume (FEV1) in preterm babies without broncho-pulmonary-dysplasia when compared to term babies. In fact infants born late preterm ie (33–36 weeks of gestation) exhibited respiratory irregularities, such as a rise in residual volume, a deterioration in respiratory compliance, and a fall in the ratio of expiratory flow to inspiration.

Poorer lung functioning and airflow restriction in adulthood are linked to preterm delivery, with the degree of prematurity having the highest correlation.[30,34]

In a study on the cardiac-renal implications of low birth weight and preterm birth with a 40-year follow-up, De-Freitas MJ, Katsoufis , and Abitbol found that persons born prematurely had a twofold risk of chronic renal disease compared with term controls. Extremely premature births (28 weeks) reported a three - fold statistical risk vs to term births, with risk being significantly higher in females. Despite a 25% to 50% reduction in GFR and subclinical kidney disease, tubular creatinine secretion can maintain plasma creatinine well within normal range.[39]

According to a population-based cohort research, individuals aged 30 to 43 who were born preterm had a 53% higher relative likelihood of developing ischemic heart disease versus those who were born at their full - term, whereas people who were born early term (at 37 to 38 wk) have a 19% higher risk.[49]

Pregnancy's 3rd trimester helps to accelerate brain development by increasing the vol. of grey and white matter and proliferating axons and myelination.[50,51]

Babies born preterm have a higher risk of cerebral palsy, cognitive problems, and seizure disorder during infancy. Early preterm infants have smaller hippocampal and fronto-temporal regions than term newborns.[52]

Further periventricular leukomalacia and hypoxic injury modifies the prefrontal cortex and neural network, later probably behavioural manifestations.

Children with autism spectrum disorder who might have been born preterm had improved interpersonal communication but worse mannerisms than term children with the illness, according to research by Chen. et al. In this study two hundred forty six (87%) of the 283 very preterm survivors were followed prospectively to 5 years of age. Out of these after matching the eligibility criteria 18 preterm ASD children were compared with 44 term birth ASD children. The two ASD groups were comparable for age at examination, gender, and intelligence quotient. The two groups showed comparable ADOS severity scores in social affect deficits, restricted repetitive behaviors, and total score, but had differences in qualitative abnormalities in reciprocal social interaction.

The cognitive IQ of really preterm babies is 12 points lower when compared to that of term infants, and lifelong neurodevelop-mental problems are inversely associated to gestational age at delivery.[53]

Australia's retrospective cohort research, by Jenny Bourke, MPH, Kingsley Wong, MBBS, Ravisha Srinivasjois, FRACP et al between 1983 and 2010, disability free survival (disability defined as intellectual disability, autism, or cerebral palsy) was 42.4% for those born at 24 weeks, 78.3% for those born at 28 weeks, and 97.2% for those born at term. Of the 720901 recorded live births, 12083 children were diagnosed with disability, and 5662 died without any disability diagnosis.Estimated probability of disability free survival to 25 years was 4.1% for those born at gestational age 22 weeks, 19.7% for those born at 23 weeks, 42.4% for those born at 24 weeks, 53.0% for those born at 25 weeks, 78.3% for those born at 28 weeks, and 97.2% for those born full term.[54]

Birth wt., APGAR scoring, SEstatus, and ethnicity of the mother were certain prognostic predictors according to this study.

Although motor deficiencies in preterm infants are typically detected sooner, some of them, including such as poor head control, hypotonia, or hypertonia, are ephemeral and go away about the time the kid turns 1 yr old.[58-61]

Cerebral palsy (CP), which results from damage to the developing corticospinal tract, is the commonest form of motor disability in developed countries occurring with a frequency of two per 1000 live births.

Cerebral palsy, one of the most significant neurological side effects of preterm delivery. Childhood CP rates in survivors of extreme prematurity are 70to80 times greater than those in term new - borns.Longitudinal studies in most developed countries show a rise in cerebral palsy rates in the 1970s and 1980s and overall rates have been fluctuating since then.[58,63-65]

A case control study was conducted in 1997 to evaluate some of the known risk factors for cerebral palsy by Suvnand, S, Kapoor, S.K., Reddaiah, , et al. The study recruited 125 cerebral palsy cases recruited from hospital clinics and 125 age-and- sex-matched neighbourhood controls, every one of whom was under 5 years old and dwelt in Delhi, India. Spastic cerebral palsy emerged as the most prevalent kind (88%). The most prevalent topographical subtype (86.4%) was quadriplegia. Only 25.6% of children had birth asphyxia, it was concluded. Low-birth-weight (28.8% of cases) was the risk factor with the highest prevalence. Cerebral palsy had no discernible correlation with precipitous labour, LSCS, twin, toxaemias, breech deliveries, and head trauma.[80]

In another study by Parul Bhati, Suvasini Sharma, Ridhimaa Jain, et al to study clinics etiological profile and comorbidities in cerebral palsy, done on 160 children with CP in the age range of 2to15 years in a tertiary care hospital in Delhi in 2019 found that more than half of patients—64.4%— were under the age of 5 and the majority of those (72.5%) were males. Birth asphyxia (41.9%) constituted the most typical aetiology.

The vast majority of individuals (43.1%) had bilateral spastic CP (spastic quadriplegia).

All CP subtypes demonstrated that cognitive impairment > epilepsy was the most frequent comorbidity. Comorbidities such epilepsy, all visual impairments besides optic atrophy, chewing and swallowing troubles, and epilepsy were more widespread in spastic quadriplegic CP patients. In dyskinetic CP, hearing loss, speech difficulties, and optic regression were more prevalent.[76]

In this research study, 55.6% of individuals had epilepsy. From 30% (Hagberg et al.) to 70% is the reported incidence of epilepsy in people with cerebral palsy in the literature (Stanley et al.). In a number of studies, Singhhi et al. found that 32% to 35.4% of CP children also had epilepsy.[77-79]

Table 3 [76]

	<28 weeks	28–31 weeks	32–36 weeks	>36 weeks
Live births	1.937	4.803	46.774	711.525
Registered cases	109	174	174	571
Incidence rate	56.27	36.23	3.72	0.80
Incidence rate, 95% CI	46.86–6.44	31.30–41.89	3.21–4.31	0.74–0.87
CP risk <28 vs. >36 weeks	Relative risk 70.12; 95% CI 57.41–85.64			
CP risk 28–31 vs. >36 weeks	Relative risk 45.14; 95% CI 38.19–53.57			
CP risk 32–36 vs. >36 weeks	Relative risk 4.64; 95% CI 3.91–5.49			

CP, cerebral palsy; CI, confidence interval. Children born in Portugal between 2001 and 2007 (n = 1,098). The lower risk group (<36 weeks of gestational age) is considered the reference group to cerebral palsy relative risk calculation at 5 years of age. Data from October 31, 2016. Reproduced with permission from reference [76].

Retinopathy of Prematurity is the main cause of visual deficit in preterm infants. The combination of developmental perturbation of the visual system spurred on by preterm delivery and/or neurological problems, o2 toxicity, infection, glycemia abnormalities, undernutrition, and genetic predisposition puts such infants at a heightened risk of developing long-term visual disorders. Prematurity is the major predictor of ROP, as it is a progressive illness distinguished by fibrovascular proliferation at the retina's periphery and a risk of retinal detachment.[65-68]

Sujit S. Patel, Niranjan Shendurnikar,Department of Pediatrics, K.G. Patel Children Hospital, Vadodara, Gujarat, India conducted a study on RoP in India: its incidence, and outcome and the applying currently available screening criterias.

Conclusion was that prenatal steroid usage, birth asphyxia, sepsis, multiple blood transfusions, pulmonary distress syndrome, multiple delivery, gestational age, and birth wt alone weren't the sole risk factors a/w RoP. Likewise, it was shown that the prevalence of RoP is rising, notably in developing countries and that this trend includes newborns with higher birth - weight and gestational ages.

Of 286 babies evaluated, 69 were positive for RoP. Hence incidence was 24.1% in current research. There was no statistically significant association with gender for occurrence of ROP.[69]

It was comparable like in Maaheshwari R et al, (20%), Chaudhary S et al, (22.3%) and Goyal et al, (25.4%).[70-72]

Table 4 [69]

Comparison of ROP positive cases between ≤34 weeks and >34 weeks and ≤1500 grams and >1500 grams.

		Retinopathy of prematurity		Total	X^2 value	p-value
		Present	Absent			
Gestational age (Weeks)	≤34	47	62	109	34.709	<0.001
	>34	22	155	177		
Birth weight (Gms)	≤ 1500	35	19	54	60.207	<0.001
	>1500	34	198	232		

A retrospective cohort study by Freitas, A.M., Mörschbächer, R., Thorell, M.R. *et al.* was done to study the incidence and risk factors for retinopathy of prematurity of preterm infants born, study was conducted in a tertiary neonatal intensive care unit was from March 2005 to August 2015. Six hundred and thirty-nine preterm newborns were included. Mean gestational age was 30.7 ± 2.5 weeks and incidences of ROP at any stage and of type 1 prethreshold ROP were 33.9 and 5.0% respectively.This study found a significant incidence of ROP (33.9%) in the studied population, and highlighted pulmonary diseases as a significant risk factor for type 1 prethreshold ROP.[66]

Another huge concern with prematurity is hearing impairment, which can have a negative impact on the acquisition of language, acquiring knowledge, effective communication, life quality, and adult financial freedom. These infants have difficulties with central auditory processing, together with a worse capacity to distinguish simple speech sounds than their full-term counterparts.

The vestibular organs, cochlea, auditory nerve, & cortex can suffer irreversible damage from hypoxic injury, hyperbilirubinemia, infectious diseases, ototoxic pharmaceuticals, and loud exposure. Admission to the NICU for more than 5 days is a risk factor for hearing loss, regardless of other medical diagnosis.

In order to effectively and timely introduce hearing aid use, surveillance is required as hearing loss might be progressive and identified late in life (between the ages of 2-4yr)[87]

Prematurity has grave ramifications, including hearing impairment. Its occurrence is inversely correlated with the baby's developmental stage.

A study correlating prematurity and SNHL was carried out by Elaine S Marlow, Linda P Hunt, Neil Marlo Professor E S Marlow, Department of Child Health, Level E East Block, Queens Medical Centre, Nottingham NG7 2UH, UK in infants < 33 weeks gestation with significant SNHL born between 1 January 1990 and 31 December 1994.It was found that children with SNHL had longer periods of intubation, mechanical ventilation, oxygen requirement, and acidosis, and more frequent treatment with dopamine or frusemide. Duration of jaundice and levels of bilirubin were similar between the groups.[88]

According to the study in preterm babies, the coexistence of risk factors for hearing loss may be more important than the individual factors themselves.

In a study by Katarzyna Wroblewska-Seniuk et al database of the Poland's Newborn's Hearing Screening Program from year 2010to2013 was analysed for hearing impairment in premature newborns . It was comprised of study group (infants< 33wkGA) and the control group infants. Hearing impairment was determined in 11%infants ≤ 25 POG, 5% b/w 26–27 POG, 3.46% in 28wk POG and 2–3% b/w 29–32wk POG whereas babies of control clan had incidence of 0.2% (and 2.87% with associated risks).

It was concluded that most common risk factor were cranio-facial malformation, VLBW, low APGARscore and support of mechanical ventilator.[86]

In a recent study by Saugata Chaudhuri, Suchandra Mukherjee, Tanmoy Kumar Bose, Turna Roy Chowdhury in 2021 to estimate the burden of language, cognition delay and hearing impairment in preterm infants and to identify the perinatal and neonatal risk factors for atypical outcome concluded that early anticipation and early identification of abnormal hearing, language and cognitive outcome of VLBW infants can be used as simple and cost-effective measures for preventing long-term morbidity at resource limited countries.[85]

Particularly when they are in school, preterm survivors have significant rates of cognitive impairment and emotional problems that impair their academic performance.

Very preterm children score much worse on the intelligence quotient than their term classmates, according to case-control studies.

Environmental factors, like as parental financial level and education, appear to have an impact on cognitive derangements. Many of the issues continued into adolescence age, according to follow-up surveys, and protracted monitoring was necessary for cognitive problems and educational demands.[90-92]

The EPIPAGE study cohort found cognitive deficits in 31% of surviving children at 8 years old. People born prematurely have lower IQ (approx. 0.82 SD), lower executive functioning (0.51 SD), and lower processing speed (0.49 SD) than term born controls[58,59]

The Extremely Low Gestational Age Newborn (ELGAN) cohort concluded that at the 10- year follow-up in children without intellectual disability (verbal and nonverbal IQ > 70) low achievement in math was 27% which was 1.5 times higher than the risk of low reading which was 17%.[58,59]

Language impairments in its various dimensions, such as receptive, articulation and expressive, , have been recorded in infants born preterm.

Current Problem

By providing every mother and child with the necessary prenatal, postpartum, and intrapartum care, as well as prenatal steroid injections to expectant women at risk of preterm labour, KMC care, and drugs to treat neonatal infections, it is feasible to safeguard premature babies.

By providing every mother and child with the necessary prenatal, postpartum, and intrapartum care, as well as antenatal steroid injections to pregnant women at risk of preterm labour, kangaroo mother care, and medications to treat neonatal infections, it is possible to preserve premature babies.

Continuous midwife-led care has been demonstrated to lower the risk of preterm by about 24% in settings with effective midwifery services.

Starting with a healthy pregnancy is the best method for avoiding preterm birth-related fatalities and problems. All women will have a favorable pregnancy experience and result if they access quality care before to, throughout, and after their pregnancies.[2]

Early Intervention Practices for Preterm Infants in NICU care

Over the past 20yrs, there's been an increase in the survival of small, gravely ill preterm babies, but at the penalty of a greater strain of neurological co-morbidities.

Early intervention (EI) exploits of neuroplasticity's distinctive property, which reduces or ameliorates the deleterious repercussions of insults to the developing brain during the foetal and early neonatal period. EI also enhances neuro-behavioural maturation and pleasurable sensorimotor experiences, which can lessen negative outcomes for these high-risk infants.

Quality of newborncare is measured by intact survival, rather than merely survival.[109-111]

Preterm infants are at greater risk for neurodevelopmental disabilities than term infants. Interventions supporting parents to improve the quality of the infant's environment should improve developmental outcomes for preterm infants.

According to a Cochrane database systematic review which included a study done in 2012 by Spittle, OrtonJ, Anderson P, BoydR, Doyle LW et al to assess early developmental intervention programmes post-hospital discharge to prevent motor and cognitive impairments in preterm infants was reviewed and it was found that Gestational age is related to cognitive and motor competence.[93-96]

In the study infants born <34 wks of GA have 3times the risk of disabilities/deficiencies in multiple domains of neurological development in comparison with peer term infants.

At 4yrs of age, about 1/3rd of extreme preterms have evidence of cognitive dysfunction, and 21percent of extreme preterms show cognitive dysfunction at 6yrs compared with 1percent of full- term peer infants. All in all, nearly 1/2 of the preterm have some form of impairment/disabilities. Also late preterms (ie, delivered b/w 34 and 37wks of gestn) have RR of 1.13 for disability by 3yrs of age, with continuous increased risk of neuro-develop-mental disabilities and poorer motor performance than term infants.[93,95,96]

According to a Cochrane database systematic review, 13 out of 21 research studies reported evaluations at infancy and met eligibility requirements, however only 3 of the studies found that the test subjects had significantly improved cognition. It was established that early intervention programmes boost infants' IQ-measured cognitive outcomes by over 1/3rd of a SD from the mean.[93-96]

The Infant Health and Development Program was the only one to monitor infants up to 18yrs old, and by that point, no overall variations in cognitive standardised test scores between the control and intervention groups had been found.

The meta-analysis included 10studies with neonatal outcomes, but only 1 of them revealed a significant difference in motor development between the control and the intervention groups.

Table 5

Summary of Early Intervention in the Neonatal Intensive Care Unit [110-119]

Supportive positioning and handling	swaddling, nesting (maintain a flexed posture) regular change in position - prone, supine, upright, lateral (for GERD), head end elevation Improve the developmental positioning of babies using validated objective measures like the Infant-Positioning-Assessment Tool (IPAT).
Evoked potential audio interventions	45 dB of background noise Maternal noises (reading, conversing, and singing) begin at 28wks PMA. classical music and uterine sounds
Tactile-intervention	Care clustering KMC/GHT before 32weeks PMA holding for a brief time Massage
Kinaesthetic-intervention	Free and unrestricted motion Therapy using movement mimicry
Vestibular Intervention	Gentle handling Swaddling during transfers/ transport (gradually increase frequency & duration)

Olfactory & gustatory interventions	Avoid using strong-smelling massage oils and avoiding opening alcohol wipes or bottles near the baby. Expose the smell of breastmilk to the baby by placing the mother's breast pad nearby or by dabbing a tiny bit of breast milk on the tongue or lips. keeping a fabric soaked in milk or smelling of the mother close to the baby Oromotor stimulation/NNS starting at PMA wk 29
Visual-intervention	Dim environment until 32wks PMA Cycled light Interaction with people to promote visual attention beginning at 36 wks with ambient lighting of <646 Lux Exercises in visual stimulation for CVI using reflective objects and high contrast (black& white) pattern charts
Reducing stress & pain	documenting of discomfort and stress using a recognised pain assessment measure, such as the CRIES, NIPS, or PIPP. Non-pharmacologic ex. swaddling & KMC care, breastfeeds and/or pharmacologic methods like oral sucrose & topical analgesia with EMLA prior to all stressful interventions

Protecting & promoting sleep	During wakeful states, provide non-emergency caregiving activities. helpful tucking, swaddling, and skin-to-skin intimacy Keep sound & light intensities within the defined range. Circadian rhythm development and nocturnal sleep support can be achieved with cycled illumination
Providing Nutrition	Initiate early enteral nutrition KMC, maternal involvement in child care, and maternal drive for early and frequent breast milk expressing
Skin care & protection	Using a credible assessment tool, assess skin integrity and document it (NSCS, NSRAS) Apply protective skin creams such as Duoderma or Tegaderm to areas that will receive a lot of tapes. Applying & removing adhesive products delicately To prevent skin burns, switch the probe position every shift.
Partnering parents and family members	24 hrs access to neonate Involving parents/mother in baby care Parental education & motivation

A 2009 Cochrane review examined the effectiveness of early developmental interventions post discharge from hospital for preterm infants on motor and cognitive development. It was found that early interventions have a significant impact on cognitive development at infant and preschool age, however, there is little evidence of an effect on motor development.

In a Randomised controlled trial by Kanagasabai, 2013India, done on preterm babies between 28-36 weeks POG and birth weight 1000-2000g, early intervention in form of multi sensory stimulation was given (auditory, tactile and vestibular) when neonates reached 33wks of GA and within 48hrs of birth for babies born at 33–36 wk. Neuro-motor development was assessed by Infant-Neurological-International-Battery. Infants in the experimental group had significantly improved neuro-motor development when assessed at 38-40 wks PMA than comparators.[120]

In another Pilot RCT by Smith, 2014, USA neonates <30 weeks or ELBW were sensory stimulation (tactile stimulation), begun when the baby reached 30wks of gestation and was delivered by a nurse or another member of the research team. The massage technique was used for 7 mins, 6 times/wk for a total of 5wks. After the 5 wks of intervention, at 35 wks, PMA.

NICU Network Neurobehavioural Scale was used for assessment and no significant difference was found between intervention and comparator group.[123]

Infant massage therapy is an inexpensive and simple tool that can be utilised as part of the developmental care for a preterm infant. Recent research has shown that the significant benefits of infant massage therapy ie increased weight gains, improved developmental scores, and earlier discharge from the hospital etc, far outweigh the minimal risks ie overstimulation or injury to the baby.

In most studies preterm infant massage have combined tactile (massage) and kinaesthetic (exercise) stimulation, it is unclear whether the tactile or the kinaesthetic component is responsible for the increased weight gain observed in these studies.

Tactile and kinaesthetic stimulation promotes preterm infant weight gain via different underlying mechanisms. Preterm infant cardiac vagal activity has not been assessed independently for kinaesthetic and tactile stimulation, however studies with adults suggest that passive exercise, which is analogous to the kinaesthetic stimulation in preterm infants inhibits cardiac vagal activity while moderate pressure stroking which is analogous to the tactile stimulation used with preterm infants, increases cardiac vagal activity.[150]

In a study by Yu, 2019, Taiwan, preterm infants between 32 to 36 weeks POG and birth weight between 1000 - 2000g were included through Parental-Participation-Programme. During the patient's time in the NICU, physical therapists, parents, and nurses provided five 1-hour sessions of intervention. Neurobehaviour development was assessed at 40 weeks CGA using NNE (Chinese version) and was found that neonates in the experimental group had much improved neurobehavioral development (motor&tone patterns score)[121]

History

Infant massage is an ancient technique and was 1st discovered in China in 2nd century BC and shortly after in India and Egypt. Hippocrates', in 400 BC, has defined the above medicine - "the art of rubbing."[142]

Massaging the newborn has been a tradition in India and other Asian countries since a long time. In the western world, there has been a recent surge in the use of this ancient art, particularly as therapy for parents and professionals.[144]

Egyptian tomb drawings in 2500 BC showed the massage therapy and were the pioneers for reflexology.India had the first known written massage therapy traditions around 1500 BC, though the practice may have actually originated around 3000 BC or earlier.[142,143]

In the early 1800s Swedish doctor Per Henril Ling developed the 'Swedish Movement System', which is regarded as the foundation to Swedish massage and today the Swedish massage is one of most common types of massage practiced in the western hemisphere, as well as the Japanese massage practice of Shiatsu. Miami's Touch Research Institute was founded in 1990 to investigate many facets of this topic.

In 1993, the Mothers in Calcutta were observed by the Touch Research Institute at the University of Miami School of Medicine while giving their newborn newborns a customary Indian massage. They had seen that the babies slept well after the daily massage, which was very forceful.[141]

Further investigation revealed that baby massage was practised daily in various nations after the child took a nightly bath, and the outcomes were the same: happy, sleeping babies.

Additionally, infant massage has a deep historical foundation. In China, the practise of massaging infants dates back to the Qing dynasty (1644–1911). (T. Field, S. Schanberg, M. Davalos, and J. Malphurs).

Ayurvedic treatment, which originated in India around 1800BC, also has long-standing historical origins in infant massage.

Neonatal massage practice has been predominant for decades' in Indian-subcontinent. Daily massage is perhaps the simplest yet most loving gift mother can give to a child. Baby massage, an ancient Ayurvedic custom is still practiced to this day in our country India.[144]

Massage is employed as part of the baby's normal bath ritual in some cultures, including the Maoris and the Hawaiians.

When he produced a photojournalistic book on the Indian practise of baby massage in the 1970s, French doctor and pioneer of the natural childbirth movement Dr. Frederic Leboyr is credited with helping to popularise infant massage (Spehar,2001).[145]

At the request of childbirth educators, Vimala Schneider Mc Clure created a training curriculum for baby massage instructors in 1978, spreading the practise to the US for the first time.

McClure established the International-Association of Infant-Massage (IAIM) in 1986, and as of the year 2000, there are already 27 chapters (Spehar, 2001).[129]

Tactile and kinaesthetic stimulation therapy of preterms giving moderate pressure was introduced in the year 1986.

This comparable protocol has been employed in the majority of replication studies. The first 5mins of this protocol are spent stroking the infant's head, shoulders, arms, back, and legs with moderate pressure. The next 5mins are spent doing kinaesthetic stimulation, which involves having the infant lie on their back and moving their legs and arms in flexion and extension like they are on a bicycle. The final 5 mins are spent stroking the baby as in the first 5 mins.

There is perception of the society about massage in newborn is that it prevents cold/cough, provides warmth to the baby, keeps their skin smooth and makes the bones stronger. It has been observed that massage was more prevalent in home delivered infants as compared to those born at a health- care setting.

. The massage therapeutic intervention was usually started in initial few days of life and usually carried out by grandmother or any elderly lady at home.[146] It is often preferred to massage a newborn using lubrication in place of no lubricant in order to lessen friction between the surfaces. Either oil or powder may be utilised as the lubricant.Instillment of oil in the infants' ears and nose forms a popular practice in India.[147]

Such traditions are likely to undergo modifications with present access to information at hand and diverse exposures to numerous cultures from around the world.

For instance, child birth that was perceived as a natural process conducted at home with support from birth attendants has shifted to the medical domain in the control of skilled birth attendants globally.

Definition

Touch refers to contact between objects. In newborns it can be active or passive. Passive touch can be delivered as a care touch or massage.[138,139]

A methodological touch intended to stimulate the baby is referred to as massage

The term "positive touch," which Cherry Bond coined, refers to a variety of newborn contact interactions, including massage.[140]

The manual application of a specific technique to every area of the body, from head to toe, is what is alluded to as a massage intervention. This is commonly conducted by the mother's hands. This massage intervention technique uses a systematic external application that is pre-structured, including caressing, stroking, stretching, compression, and active or passive flexion and extension motions that fall within normal range of physiological motion.[132]

Tactile Stimulation [132-133]

The amniotic fluid that the foetus is bathed in during pregnancy provides it with comprehensive touch and sensory experiences. Preterm children in NICUs are denied the consistent tactile stimulation of amniotic fluid and are vulnerable to a variety of touch stimuli when being addressed during routine nursing and medical procedures.

According to research findings, hypoxia, bradycardia, sleep disturbances, elevated intracranial pressure, and behavioural agitation are still only a few of the negative impacts of such handling practises that have been witnessed. As a result, it is advised to provide enhanced tactile stimulation while also guaranteeing limited and gentle handling.

Kinaesthetic Stimulation [132-133]

Owing to hypotonia, the spontaneous movements or activity of the extremities is massively diminished in preterm and very low birthweight newborns.

Nevertheless, infants are further denied of such physical activity in the NICU due to the swaddling and minimal handling necessities.

According to studies, range-of-motion activities, passive weight bearing, and modest longitudinal compression of the extremities all contribute to enhanced weight gain, bone width, and bone mineral density.

Various Massage Techniques[145]

Indian milking - involves encircling the leg and moulding the hands to it, one after the other, using the inside edge of each hand to milk it. The ankle is softly held by the opposing hand. The inside hand should climb the leg to the ankle, while the outside hand should cross the buttock. Utilizing your lower back or pelvis as your centre of gravity, move in rhythmic strokes.

Squeeze and twist - Clasp the leg with the inside edges of your palms facing up and squeeze and twist. In order to avoid twisting the knee joint, keep your hands close together and try to fully encircle the leg. Caress from the thigh to the ankle while softly circling in the opposite directions, back and forth, and lightly compressing. This movement across the muscle aids in muscular relaxation.

Swedish-milking technique - involves stabilising the leg at the ankle and milking the leg from the ankle to the hip with 1 hand on the outside and the other on the inside. Do not lift the infant's body off the ground.

Effects of tactile and kinaesthetic therapy [149-156]

1. Weight gain:

It is the aspect of massage therapy in newborns that is the most reliable.

In a study by Scafiidi et al. 40 preterm newborns with a mean GA of 30 weeks and a mean birthweight of 1.17kg were administered to tactile/ kinaesthetic stimulation 3times/day for 15mins each for 10days. It was determined that newborns who received massage gained weight 21% more swiftly (34 g vs 28 g). In a another trial, identical massage treatment sessions were given to premature newborns (mean GA: 31wks; mean birthwt: 1280g), and the wt gains was found to be 47% greater.[148]

2. Sleep-wake pattern:

Infants receiving tactile and kinaesthetic stimulation seem to be more active-alert and exhibit less time sleeping.

Infants under 36 wks of GA (birth wt <2.5 kg) who were massaged up to 8 months old had superior sleep quality and reduced sleep disruption, according to a study by Kelmanson' et al. The daytime was when these babies were more active. Additionally, it sped up the process of falling asleep.

When a baby is massaged, their sleep habits frequently appear to change; they seem to go asleep earlier and deeper and awaken earlier with better alertness and activity.[157]

3. Preterm -Infant behavior:

On the Brazelton behaviour assessment scale, preterm infants who received massage intervention therapy fared better in terms of orientation, range of state, regulation of state, and autonomic stability.[164,169]

Another research found higher scores on mature habituation, orienting, motor, and range of state behaviour. Preterms who receive moderate pressure massage therapy are observed to be less fussy, cry less and show less stress behaviour.

Infants who receive oil massage are seen to show fewer stress behaviour in the form of grimacing and clenched fist. Massage treatment improves the mother infant interaction and thus enhances their bonding. There is reduction in maternal anxiety and stress levels too.[150]

4. Nutritional purpose:

Topically applied oil to preterm skin, since its thin and vascular, can be absorbed systemically and serve nutritional purposes.

It was observed in a study, that measured serum TGL, significant improvement was observed in preterm infants (less than 34wks gestation) who underwent oil massaging with safflower and coconut oils 4times/day for 5days.

Increase sr linoleic acid levels (EFA) was demonstrated from soybean oil (vegetable oil) massage onsmall for gestational age infants that resulted in improved anthropometric parameters.[158]

Administering 1 amongst the 3 therapies (KMC care, traditional mustard oil massaging under radiant heater, or plastic-swaddling) post delivery helped lower the likelihood of early hypothermia in the first 2hrs post delivery by nearly 50% and the incidence of late hypothermia in the first 24hrs after birth by 30percent in a study conducted in Nepal .[146]

Infants that receive massage therapy have been discovered to exhibit a greater rise in temperature. Additionally, it has been demonstrated that oil massage can improve skin texture by eliminating dead cells and lessening skin dryness and cracking. There seems to be evidence that massage therapy enhances the function of the skin's protective barrier.

5. ***Reduced mortality:***

Infants <33wks GA who had massages with topical safflower oil or moisturiser made of (petrolatum, mineral oil, mineral wax, lanolin alcohol) were shown to have a 41% reduced risk of nosocomial pathogens than controls in a randomised controlled experiment carried out in Asian ubcontinent-Bangladesh. Decreased mortality occurred in the study group as a result. It was demonstrated that safflower seed oil applied topically offers preterm VLBW infants defence against nosocomial infections.

6. Maternal benefits:

The perks of massaging their premature infants have also been felt by mothers. At least 2 recent research found that preterm infants' mothers who massaged them suffered reduced psychological discomfort. The State-Trait Anxiety Inventory scores were lower in caregivers who massaged their infants. (STAIT score) Certainly, mothers who provide tactile and kinaesthetic stimulation therapy to their neonates show more frequent attachment behaviours.

Less melancholy, anxiety, PTSD, parental stress, and HOME-scores(a measure of stimulation in the home) were observed in mothers who massaged their infants.[161-162]

The mothers who provided massages saw their depression symptoms subside more quickly. Depressed mothers who learned to massage their baby, found themselves feeling less depressed and their babies were more responsive in their interactions as a result.

Parents of the preterm infant also benefit because infant massage enhances bonding with their child and increases confidence in their parenting skills.Parents feel more confident in handling their baby.

Underlying mechanism:

Numerous hypotheses have been postulated to explain the weight gain seen in newborns who get massage therapy. At first, it was hypothesized that weight gain after massage therapy was owing to an increase in calorie intake driven on by a change in sleep–wake cycles.

However, it was discovered in a research study by Dieter, et al. that although babies who underwent massage therapy for 5days slept less all in all, their calorie intake remained consistent and did not contribute to the added weight that was seen.[163]

The duration of a 15-mins massage therapeutic session was found to significantly boost vagal activity in a study by Diego et al. As a measure of HR variability, the vagal activity was inferred from the ECG. Likewise, a considerable rise in gastric motility was observed in the hours following a massage, leading to the premise that massages increase vagal activity, which in turn improves gastric motility, which in turn leads to better nutritional absorption and, inevitably, better weight gain.[150]

Interestingly, the serum levels of insulin and IGF-1 in preterm infants who got massage therapy increased. This may possibly be the reason why massage therapy leads to weight gain.

Increased vagal activity may lead to greater weight gain by increasing gastric motility and promoting the release of insulin. Similarly, decreased cortisol lead to greater weight gain by reduced the inhibitory effects of cortisol on insulin secretion and increased IGF-1.[102,148]

Chronic high levels of cortisol inhibits growth hormone which intern stimulates production of IGF-1. IGF-1 is one of the factors mediating the greater weight gain observed in massaged pre-terms, and the reverse might also be true , that is , weight gain may stimulate release of insulin and IGF-1.[148,150]

Tactile stimulation and increased vagal activity are also associated with the release gastrin which could contribute to more efficient food absorption and energy consumption.

Babies who are massaged experience an increase in vagus nerve tone (10th CN) which will lead to increased levels of gastrin and insulin absorption enzymes. Thus the absorption of food will be better. Therefore, body weight and sleep quality increased more than those who were not massaged.

Neonatal massage has been suggested to decrease the levels of stress by decreasing the serum cortisol and norepinephrine and increased urinary excretion of epinephrine and norepinephrine.

Sympathetic maturation improvement in turn hastens pulmonary maturation. Immune function improves with neonatal massage improves the immune function by enhancing the natural killer cells (NK cells).[148-150]

Oils applied topically create a barrier against skin disruption and supply lipids that strengthen the function of the skin barrier. Infants with weak skin barrier function are more vulnerable to disease, which frequently result in bloodstream infections, the need for broad-spectrum drugs with recognised side effects, and even mortality.

Preterm infants are known to have deficient skin barrier function, but it's crucial to remember that even term infants may have subpar skin because of intrauterine deprivation.

Several hypotheses have suggested that the mechanism of pain reduction by massaging is gained through the gate theory of pain control, where massage may stimulate large-diameter nerve fibres that inhibit input from small-diameter nerve fibres.

Another mechanism by which analgesia is induced is through descending modulatory circuits by way of induction of local biochemical changes in the soft tissues, causing improved oxygenation and blood flow as well as increasing the release of certain hormones that are involved in pain perception, such as oxytocin, vasopressin, adenosine, endorphins and serotonin, and that serve as pain receptors.

Adverse aspects of massage therapy

Preterm infants are cared for in NICUs under the minimal touch policy in order to avoid infections. The potential for infection might well be increased by massage intervention.

Preterm babies with stable health conditions have been recruited in the majority of studies on neonatal massage. Massage for sick preterms has not been proven to be effective or safe.

Many babies are susceptible to allergic rashes whilst using oil. Infants on a ventilator and sick or unstable babies must n't receive massages. (Rather than, it was found that infants who had more problems benefited more from the massage and gained additional weight than infants who were medically stable.)

The use of massage treatment on newborns with heart conditions is not encouraged.

MATERIAL AND METHODS

Source of Data -

Preterm neonates in Neonatal Critical Care Unit & follow up clinic of the KAHER's Dr. Prabhakar Kore Hospital, Belagavi.

Method of collection of Data (including sampling procedure if any) -

Study Design - Randomised Controlled Study

Study duration - One year, from Jan 2021 to December 2021

Place of study - Neonatal Intensive Care Unit and follow up clinic of the KAHER's Dr. Prabhakar Kore Hospital and MRC, Belagavi, Karnataka.

Inclusion Criteria -

Preterm Infants born at <34 weeks of gestation who are haemodynamically stable and ready for discharge were included as a part of the research study.

Exclusion Criteria -

Neonates with major congenital malformations (craniofacial malformation, hypoplastic left heart, any neural tube defect, CDH (cong diaphragmatic hernia), intestinal obstruction , oomphalocoele et cetra.) were excluded from the study. Also, neonates who had undergone any major surgical interventions (thoraco-abdominal surgeries, surgery for neural tube defects etc) were not included.

Sample size

The sample size was calculated using the formula

$$n = \frac{2\left(Z\alpha_{/2} + Z_\beta\right)^2}{\left(\frac{|\mu_1 - \mu_2|}{\sigma}\right)^2}$$

$$d = \frac{|\mu_1 - \mu_2|}{\sigma}$$

Where μ_1 is the mean of the first group, μ_2 is the mean of the second group and σ^2 is the common error variance, for 95% confidence level, $Z\alpha_{/2}$ values are 1.96 and for 85% power Z_β value is 1.0364.

Here we assumed as d as large, i.e., d = 0.8, with this assumed d, 95% confidence level and 80% power, minimum sample size required is 26 per each group. Assuming 20% lost to follow-up cases , the final minimum sample size required for each group was 30 neonates.

Hence, minimum sample size required was 60 (Total=30x2=60)that is 30 samples per each group.

Statistical Analysis

Date was collected and stored in Microsoft Excel. Data was analysed using statistical software R and Microsoft Excel. Continuous variables were given in mean +/- sd/median (range). Categorical variables were represented by frequency and to check the dependency between attributes Chi-square test was used.

To compare mean/distribution over groups t-test/ANOVA/Mann- Whitney test/Kruskal-Wallis test was used. To compare the mean/distribution within the group at 2 or more time points paired t-test/ Repeated measures of ANOVA/Wilcoxon's test/Friedman’s test was used.

To compare the paired nominal data at two time points within the group, Mc-Nemar's test has been used. To check the normality of variables Quantile-Quantile (QQ) plot/Shapiro- Wilk's test was used. P-value less than or equal to 0.05 is considered statistically significant.

Infants who met the criteria for eligibility were enrolled in the study post obtaining written informed consent by guardians/parents. Infant and maternal data was recorded in a structured proforma.

A detailed neonatal information was collected. Enrolled neonates were randomised in 1:1 ratio to one of the following two study groups: therapeutic massage supplementation (intervention group) or control group.

The assignment to groups was kept in serially numbered sealed opaque envelopes and opened after obtaining consent for enrolment.

Assignment of the intervention will be done by the primary investigator.

Infant data which included demographic details , gestational age (weeks) , date of discharge , hospital stay , problems at discharge , age at enrolment (corrected gestational age in weeks) , anthropometric details at enrolment and follow up clinic and feeding method along with supplements was noted down in structured preset proforma.

Maternal data like demographic details, type of delivery , obstetric score , socio economic status was also noted to look for its effects on growth and neuro-development of the neonate.

Infants meeting the inclusion criteria and control group were enrolled in the study before discharge from NICU.

Therapeutic Massage consisted of 15 mins each session, twice a day, once in morning and once in evening (45 mins after or before feeding) which included 5 mins of the tactile stimulation therapy followed by 5 mins of kinaesthetic stimulation therapy again followed by 5 mins of tactile stimulation therapy.

Tactile stimulation was initiated by putting the infant supine on a clean, flat surface.

Next mother was advised to remove any sharp jewellery on fingers and hands and to wash hands properly before touching or interacting with the baby.

It was advised to keep the room and hands warm and baby should be awake and alert state during the massage. Coconut oil (2-3 drops, to remove friction) was used before giving tactile stimulation to the infant. The baby was undressed slowly as mother moved from head to lower limbs.

The mother was taught about infant's display signs of stress if the person delivering the massage frequently broke physical intimacy with the baby. Physical human contact with the baby was kept up at all times in a bid to make him or her feel secure and comfortable.

Tactile stimulation was continued from one part of body to other using a calm, soft beat. Fluttery or ticklish strokes were avoided through using moderate, steady motions. Every body part received 5 strokes each of tactile stimulation. It was also advised to stop the massage if baby got stressed, started crying or couldn't be consoled.

Tactile stimulation was followed by kinaesthetic stimulation which began by giving an opening stretch by holding baby's both wrist. Both arms were alternatively moved in flexion movements at the elbow joint followed by crossing each one of them turn by turn across the chest, alternating them, after that arms were stretched out alongside keeping it near to the body. Next now, legs were alternatively/simultaneously moved in flexion movements at hip joint followed by and ending by cycling the legs with flexion and extension gently moving toward the abdomen. Each movement of kinaesthetic therapy was repeated for 4 times.

Again this kinaesthetic stimulation was followed by 5 mins of tactile stimulation, and similar exercise was repeated twice a day.

Tactile and Kinaesthetic stimulation taught to the mother of babies included in intervention group on a mannequin for 1 day and from next day mother was taught the same on her baby.

Mothers were advised to continue practicing massage technique on her baby for 2 days until she was confident. Once the mother was confident and baby being discharged, mothers continued doing therapeutic massage for 6 weeks or upto 40 weeks of corrected gestational age, whichever is later.

After discharge, video and/or pictorial description of the techniques were shared with the mother and followed up about any difficulties and comprehension with the therapeutic massage through phone calls and at the time of follow up visits at high risk clinic.

Figure 1 - Tactile Stimulation

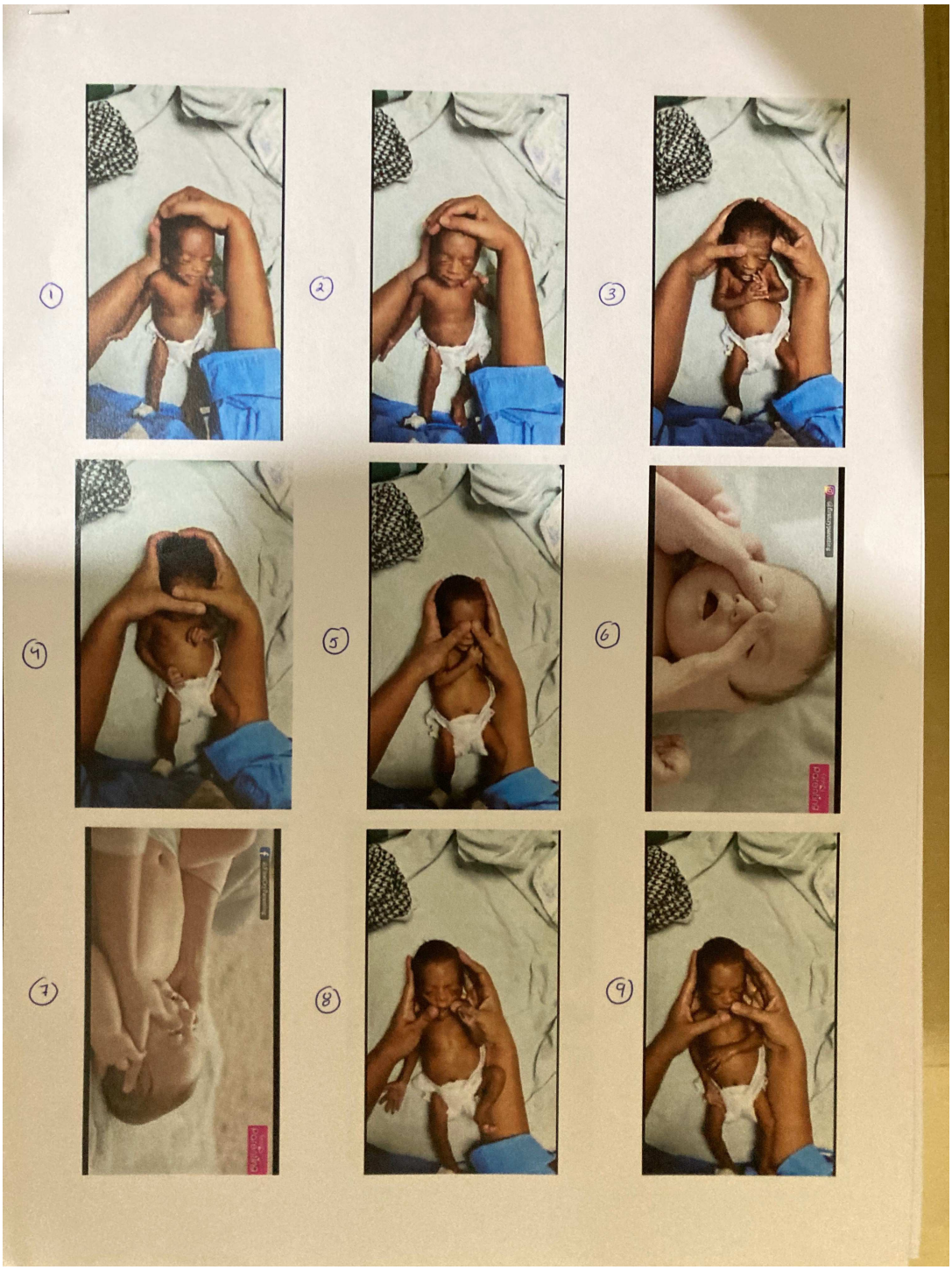
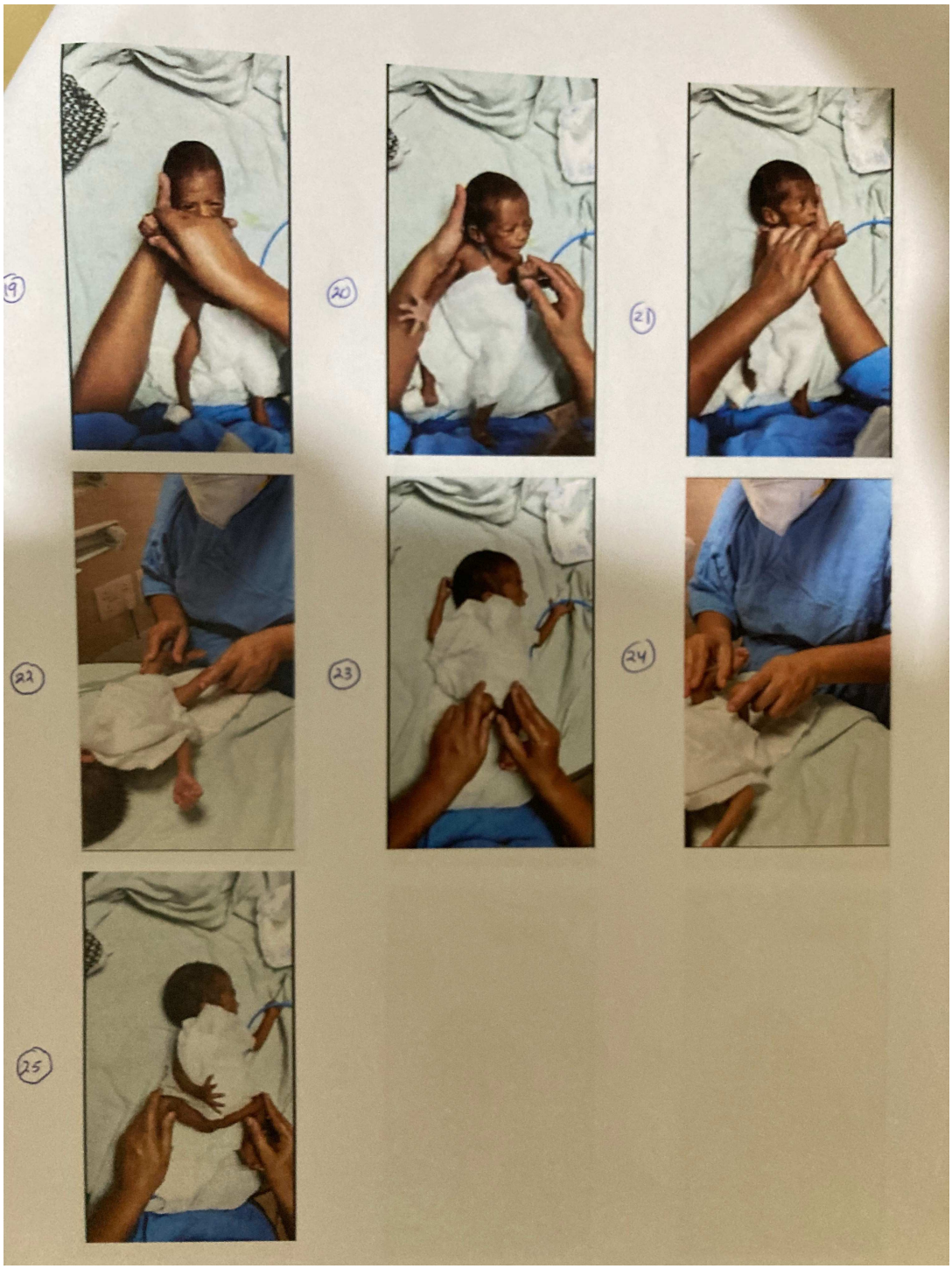


Figure 2

Figure 3

Kinaesthetic Stimulation



A log book was also shared with the mother to keep a track about the tactile and kinaesthetic stimulation being given on above mentioned time and on a regular basis.

After 6 weeks it was left to the mother that she may or may not continue doing the massage according to her wish.

Neurodevelopment assessment was done at corrected gestational age 40 weeks using Hammersmith Neonate Neurological Examination Scale and at 3 months corrected gestational age by using Hammersmith Infant Neurological Examination Scale by the Primary Investigator.

However due to COVID pandemic, and our study requiring a prolonged follow up, babies from either group couldn't be assessed by Prechtl's General Movement Assessment Scale by Secondary Investigator (blinded to intervention) as planned initially and mentioned in the synopsis.

Follow up at High Risk Baby Clinic at KAHER's Dr. Prabhakar Kore Hospital, Belagavi was done as per routine protocol during these 6 weeks after the discharge for both the groups.

STAISTICAL ANALYSIS:

Data is analyzed using statistical software R version 4.2.1. and Microsoft Excel. Categorical variables are represented by frequency and percentage. Continuous variables given in Mean ± SD / Median (Min, Max) form. Normality of variable is checked by Shapiro Wilk test and QQ plot. Chi square test is used to check the dependency of categorical variables. Two sample t test is used to compare the means of variables over groups. Mann Whitney U test is used to compare the distribution of different variables over groups. Friedman test is used to compare the distribution of variables over timepoints. Pairwise Wilcoxon test is used as post hoc analysis. Spearman's rank correlation is used to check the correlation between the variables. One-way ANOVA is used to compare the mean of variables over mother's education. Kruskal Wallis test is used to compare the distribution of variables over mother's education. Pairwise Mann Whitney U test is used as post hoc analysis. P-value less than or equal to 0.05 indicates statistical significance.

RESULTS:

Data contains measurement on 60 subjects. They are divided into two groups (control and intervention) of 30 subjects each. The following table gives the comparison of different variables over groups.

Table 6: Comparison of different variables over groups (Maternal Data)

Variables	Sub Category	Group		Total (n=60)	p-value
		Control (n=30)	Intervention (n=30)		
Age of mother (years)	Mean ± SD Median (Min, Max)	25.37 ± 5.24 24 (18, 38)	29.53 ± 3.13 30 (23, 36)	27.45 ± 4.76 27.5 (18, 38)	**< 0.001^{MW*}**
Mother's education	SSLC & less	9 (30%)	4 (13.33%)	13 (21.67%)	
	PUC	6 (20%)	4 (13.33%)	10 (16.67%)	0.1616^{MC}
	Graduate & more	15 (50%)	22 (73.33%)	37 (67.67%)	
Socio Economic	Upper (I)	3 (10%)	8 (26.67%)	11 (18.33%)	
	Upper Middle (II)	12 (40%)	11 (36.67%)	23 (38.33%)	
	Lower Middle (III)	10 (33.33%)	7 (23.33%)	17 (28.33%)	
	Upper Lower (IV)	2 (6.67%)	4 (13.33%)	6 (10%)	
	Lower (V)	3 (10%)	(0%)	3 (5%)	
Mode of delivery	LSCS	27 (90%)	26 (86.67%)	53 (88.33%)	
	NVD	3 (10%)	4 (13.33%)	7 (11.67%)	1^{MC}
Obstetric score	Multigravida	12 (40%)	14 (46.67%)	26 (43.33%)	
	Primigravida	18 (60%)	16 (53.33%)	34 (56.67%)	0.6023^{C}

*Abbreviation: C – Chi square test, MC – Chi square test with Monte Carlo simulation, MW – Mann Whitney U test, * indicates statistical significance.*

From Chi square test, it is observed that, there is significant difference in the distribution of mother's education status over groups. There is no significant difference in the distribution of mode of delivery and obstetric score.

Table 7: Comparison of different variables over groups (Neonatal Data)

Variables	Sub Category	Group		Total	p-value
		Control (n=30)	Intervention (n=30)		
Gender	Female	6 (20%)	8 (26.67%)	14 (23.33%)	
	Male	24 (80%)	22 (73.33%)	46 (76.67%)	
Hospital stay	Mean ± SD Median (Min, Max)	22.1 ± 13.2 18 (9, 56)	22.2 ± 14.95 16 (5, 54)	22.15 ± 13.98 17 (5, 56)	0.4866^{MW}
Mechanical v entilation/CPAP	No	16 (53.33%)	14 (46.67%)	30 (50%)	
	Yes	14 (46.67%)	16 (53.33%)	30 (50%)	0.6056^{C}
Major problem at discharge	Absent	19 (63.33%)	23 (76.67%)	42 (70%)	
	Present	11 (36.67%)	7 (23.33%)	18 (30%)	0.2598^{C}
Gestational age at starting of massage	Mean ± SD Median (Min, Max)	-	34.89 ± 1.03 35 (33.29, 37.71)	-	-
Gestational age at massage stopping	Mean ± SD Median (Min, Max)	-	41.14 ± 0.96 41 (40, 44)	-	-
HNNE score	Mean ± SD Median (Min, Max)	28 ± 2.52 27.5 (23, 34)	30.1 ± 2.83 31 (24, 34)	29.05 ± 2.86 29 (23, 34)	$\mathbf{0.0035^{MW*}}$
HINE score	Mean ± SD Median (Min, Max)	59.93 ± 6.67 60.5 (47, 71)	67 ± 6.73 69 (41, 73)	63.47 ± 7.54 65 (41, 73)	$\mathbf{< 0.001^{MW*}}$

*Abbreviation: C – Chi square test, MC – Chi square test with Monte Carlo simulation, MW – Mann Whitney U test, * indicates statistical significance.*

From Chi square test, it is observed that, there is no significant difference in the mechanical ventilation/CPAP and major problems at discharge over groups.

From Mann Whitney U test, it is observed that, there is significant difference in the distribution of age, HNNE score and HINE score over groups. Further, it can be noted that mean HNNE score and HINE score is higher in case of intervention group compared to the control group.

There is no significant difference in the distribution of gestational age at birth and hospital stay over groups.

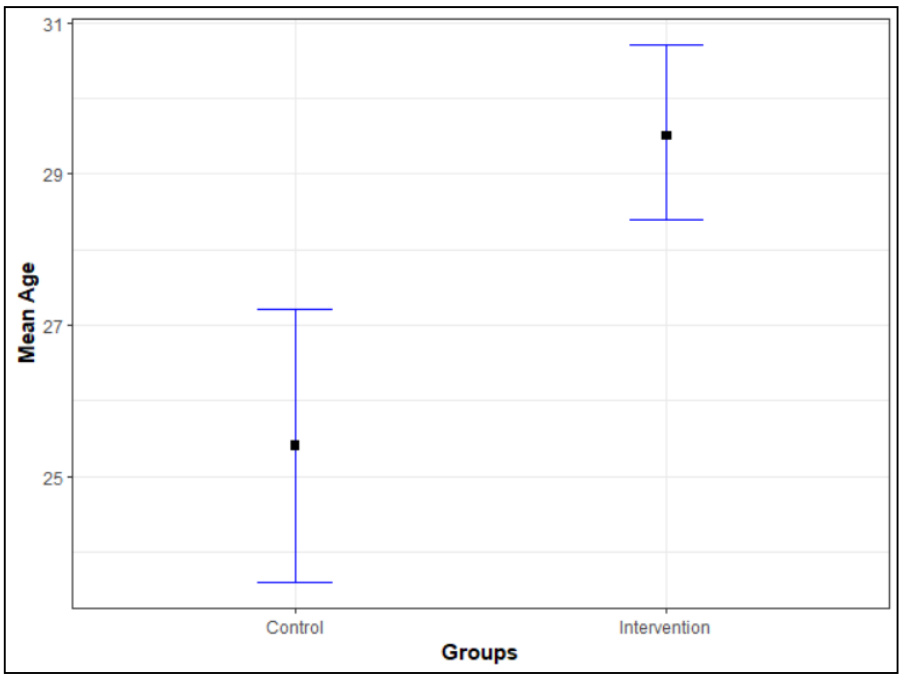


Figure 4: Mean plot of maternal age over groups.

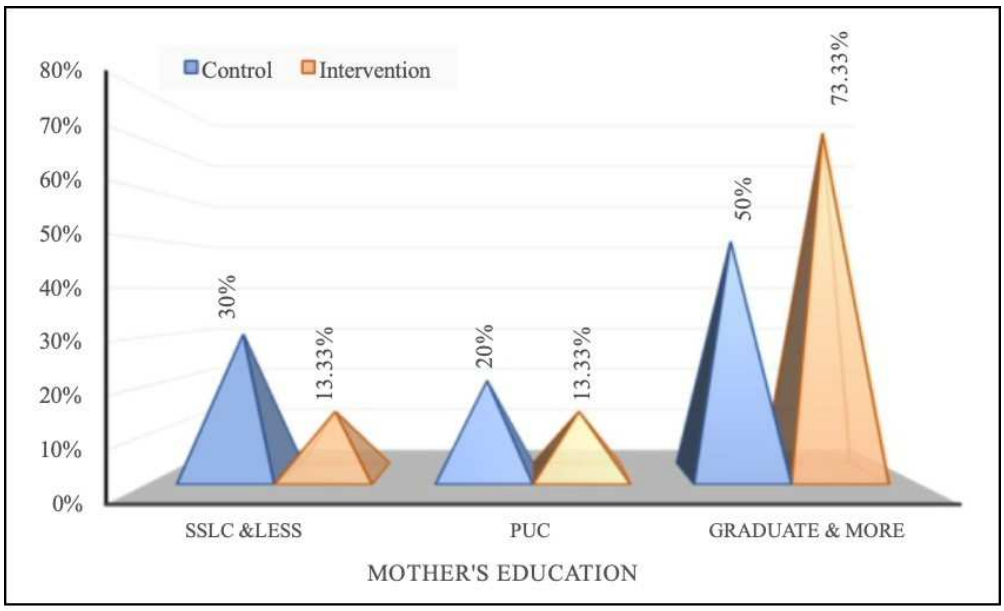


Figure 5 : Distribution of mother's education over groups

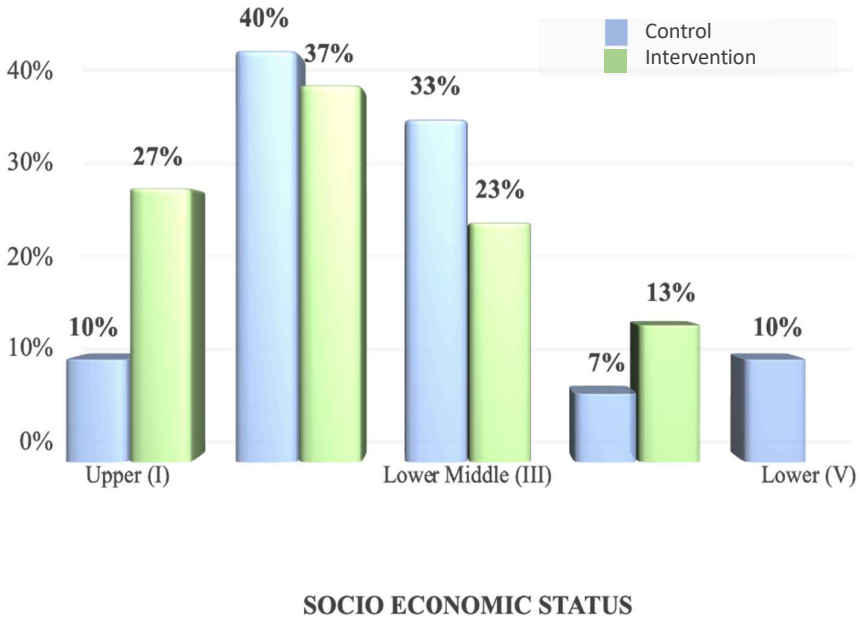


Figure 6: Distribution of socio-economic status over groups.

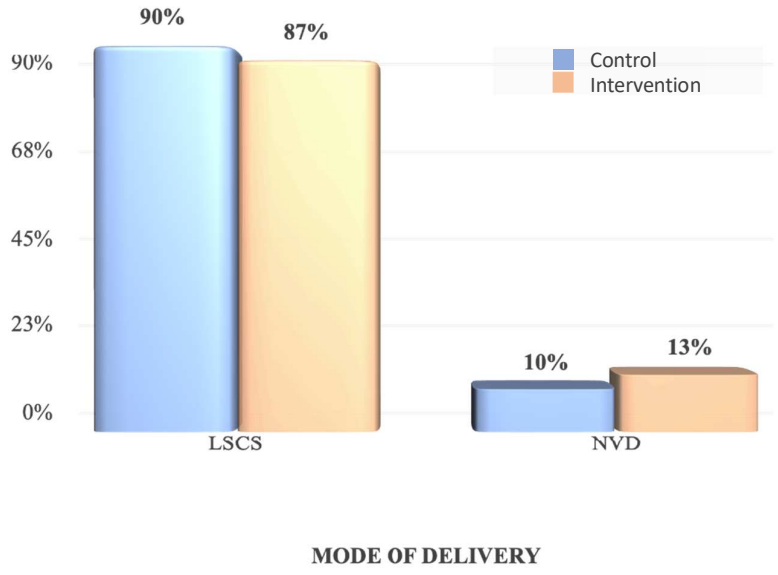


Figure 7: Distribution of mode of delivery over groups.

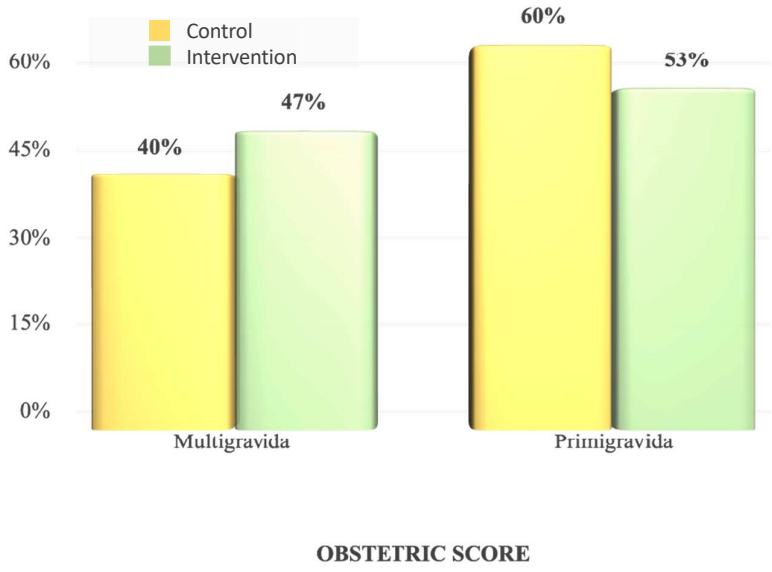


Figure 8: Distribution of obstetric score over groups.

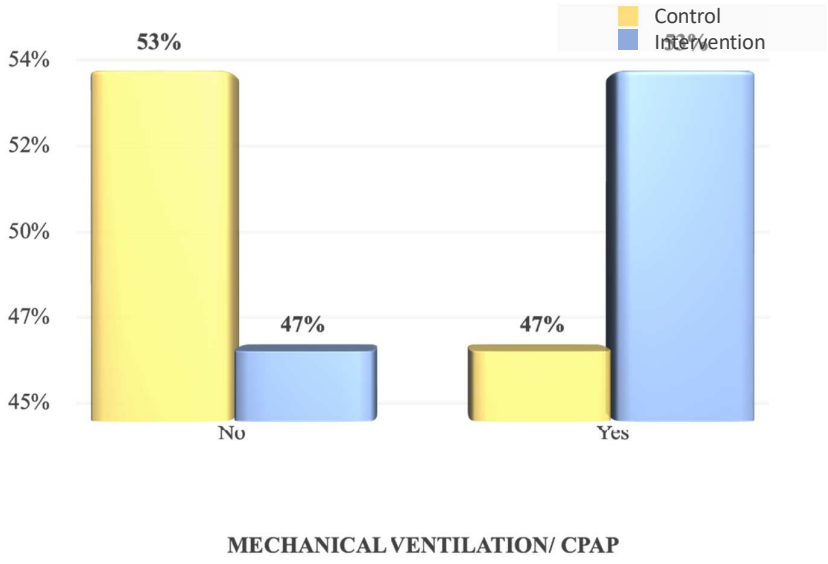


Figure 9: Distribution of mechanical ventilation /CPAP over groups.

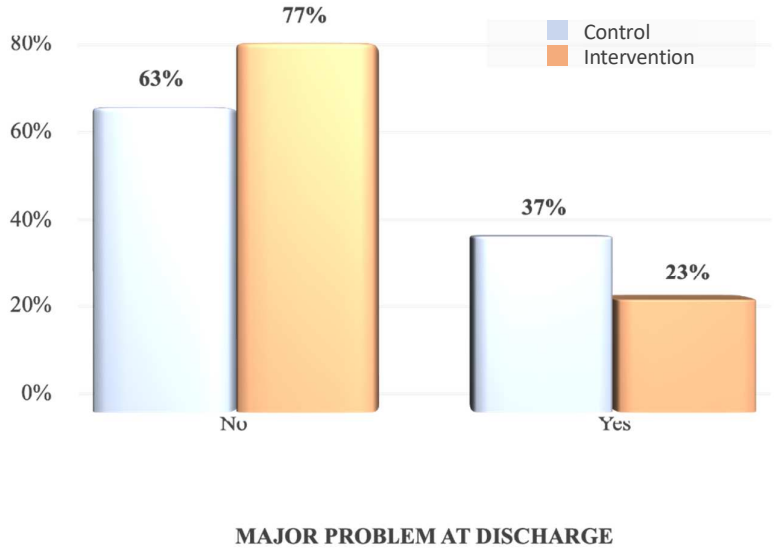


Figure 10: Distribution of major problems at discharge over groups.

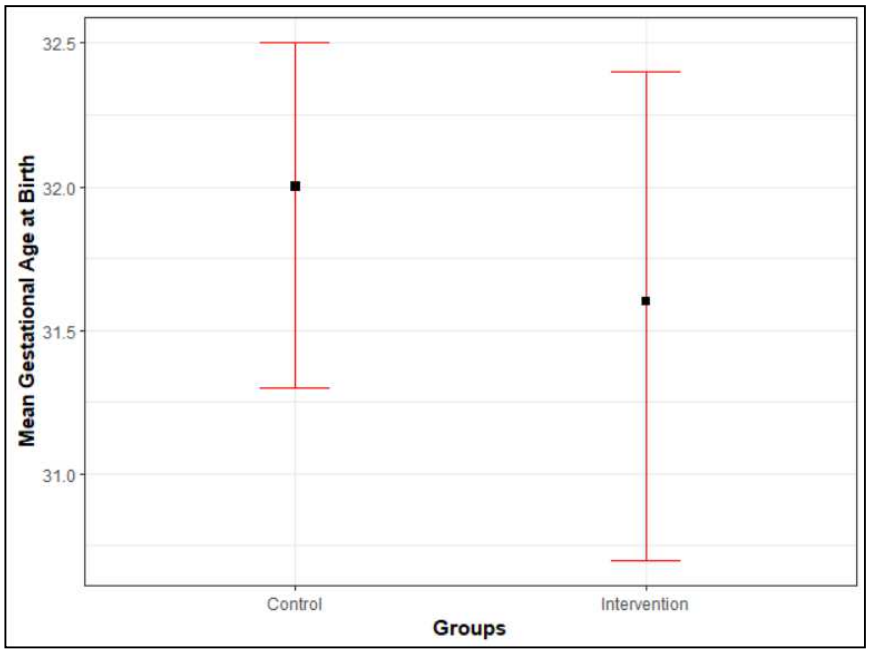


Figure 11: Mean plot of gestational age at birth over groups.

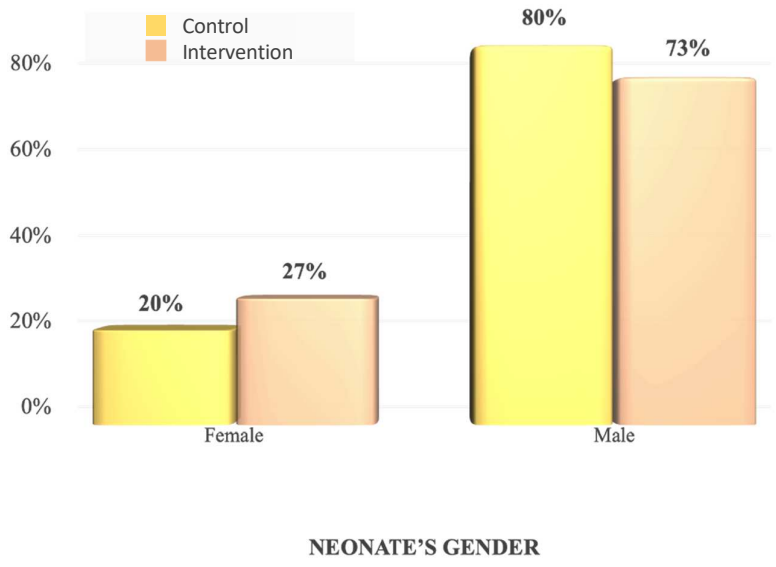


Figure 12: Distribution of infant's gender over groups.

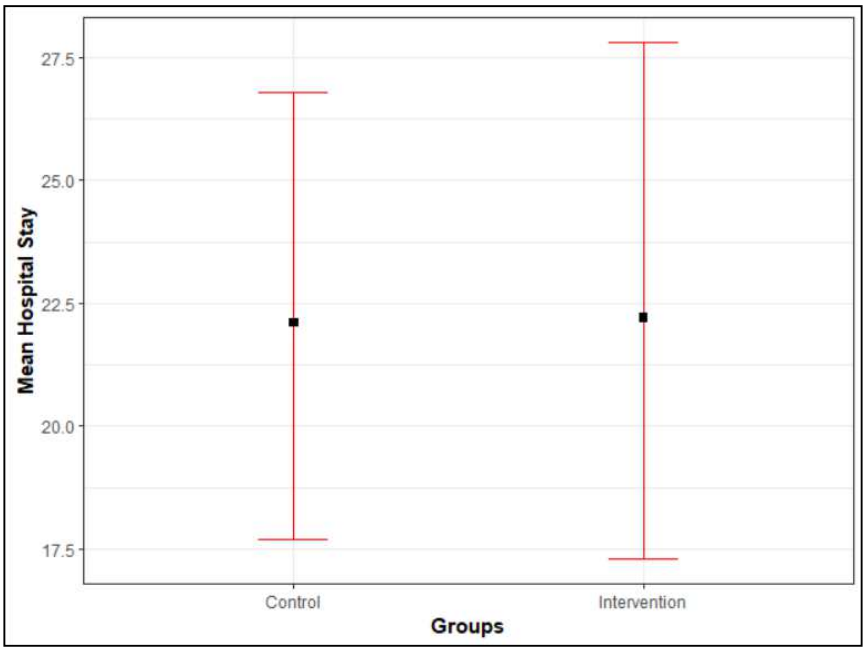


Figure 13: Mean plot of hospital stay over groups.

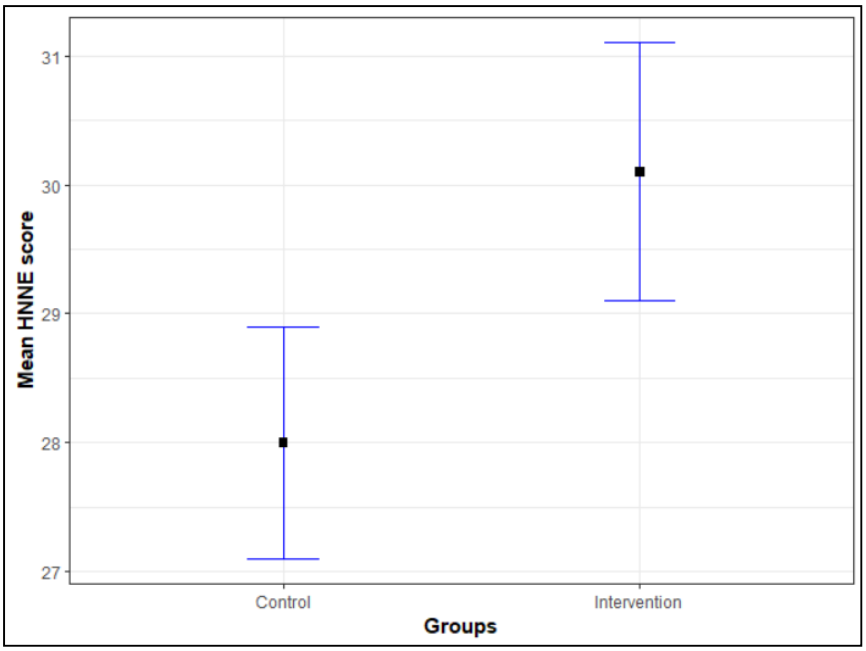


Figure 14: Mean plot of HNNE score over groups.

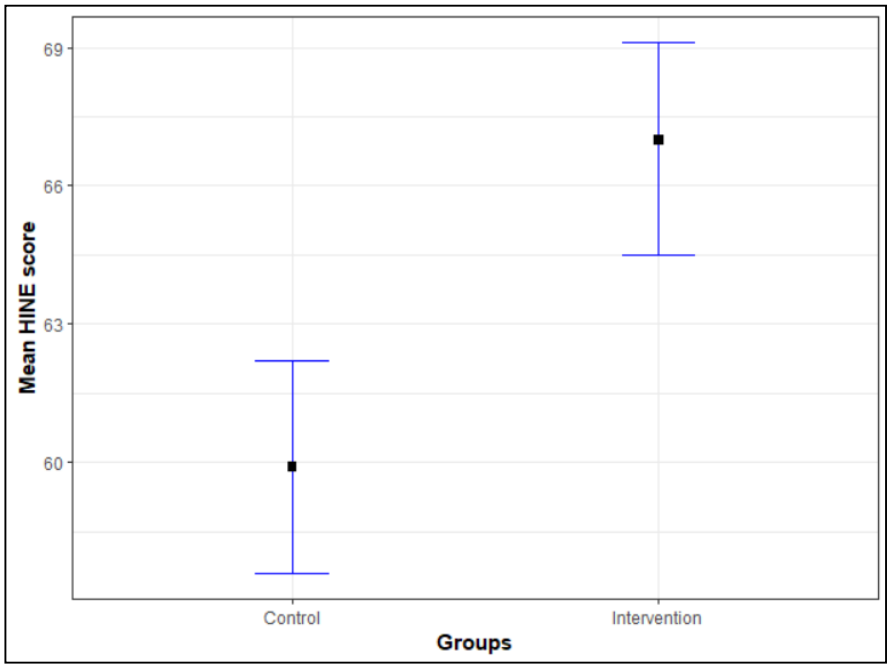


Figure 15: Mean plot of HINE score over groups.

The following table gives the distribution of major problems at discharge.

Table 8: Distribution of major problems at discharge.

Major Problem at discharge		Groups		Total (n=60)	p - value
		Control (n=30)	ntervention (n=30)		
None		15 (50%)	23 (76.67%)	38 (63.33%)	0.2598C
Apnea of prematurity		0 (0%)	1 (3.33%)	1 (1.67%)	1MC
Sepsis	Bacterial	6 (20%)	1 (3.33%)	7 (11.67%)	0.1269MC
	Fungal	1 (3.33%)	0 (0%)	1 (1.67%)	1MC
Congenital heart disease		2 (6.67%)	4 (13.33%)	6 (10%)	0.6917MC
Meningitis		1 (3.33%)	0 (0%)	1 (1.67%)	1MC
ROP		0 (0%)	1 (3.33%)	1 (1.67%)	1MC
RDS		1 (3.33%)	1 (3.33%)	2 (3.33%)	1MC
DIC		1 (3.33%)	0 (0%)	1 (1.67%)	1MC

Majority (76.67%) subjects didn't have any major problems at discharge among intervention group. Half of the control group didn't have any major problems.

Note: Few subjects had more than one major problems. Hence, total is more than 30 (100%).

The following table gives the comparison of sub components of HNNE score over groups.

Table 9: Comparison of sub components of HNNE score over groups.

Variables		Group		Total (n=60)	p-value
		Control (n=30)	Intervention (n=30)		
HNNE	Posture	8.2 ± 0.92 8 (7, 10)	8.83 ± 1.32 9 (5, 10)	8.52 ± 1.17 9 (5, 10)	**0.0122MW***
	Tone pattern items	4.57 ± 0.57 5 (3, 5)	4.67 ± 0.55 5 (3, 5)	4.62 ± 0.56 5 (3, 5)	0.44MW
	Reflex items	4.2 ± 1.32 4 (2, 6)	4.67 ± 1.21 5 (2, 6)	4.43 ± 1.28 5 (2, 6)	0.1649MW
	Movements	2.97 ± 0.18 3 (2, 3)	3 ± 0 3 (3, 3)	2.98 ± 0.13 3 (2, 3)	0.3173MW
	Abnormal signs	2.77 ± 0.57 3 (1, 3)	2.83 ± 0.53 3 (1, 3)	2.8 ± 0.55 3 (1, 3)	0.4832MW
	Behavioural signs, vision,	5.3 ± 1.24 5 (3, 7)	6.13 ± 1.14 7 (3, 7)	5.72 ± 1.25 6 (3, 7)	**0.0067MW***

*Abbreviation: MW – Mann Whitney U test, * indicates statistical significance.*

From Mann Whitney U test, it is observed that, there is significant difference in the distribution of posture and behavioural signs, vision, hearing scores over groups. There is no significant difference in the distribution of tone pattern, reflex items, movement and abnormal signs scores over groups.

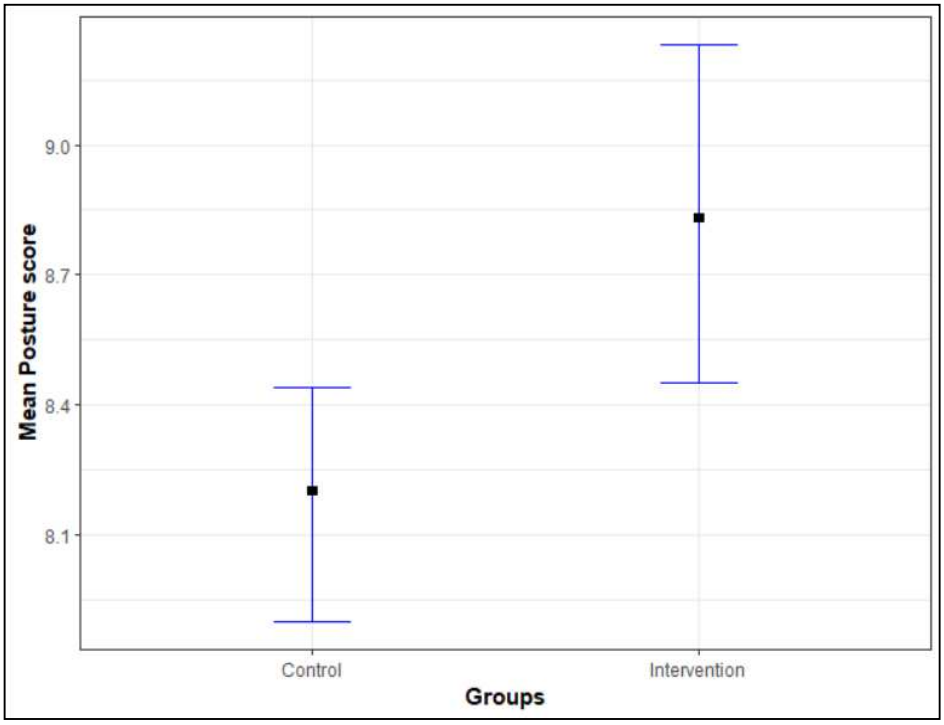


Figure 16: Mean plot of posture over groups

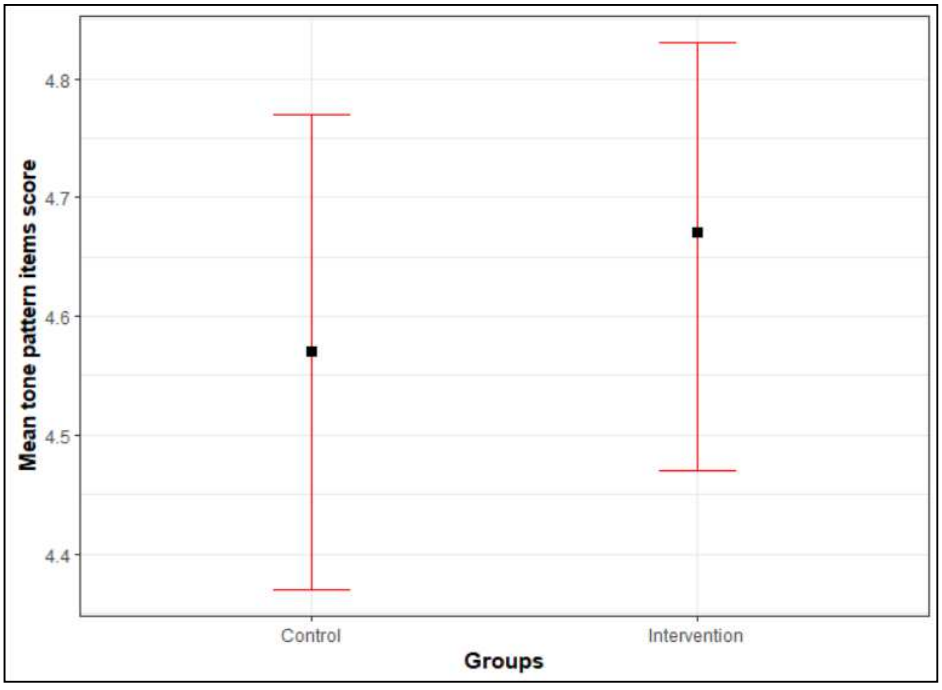


Figure 17: Mean plot of tone pattern items over groups.

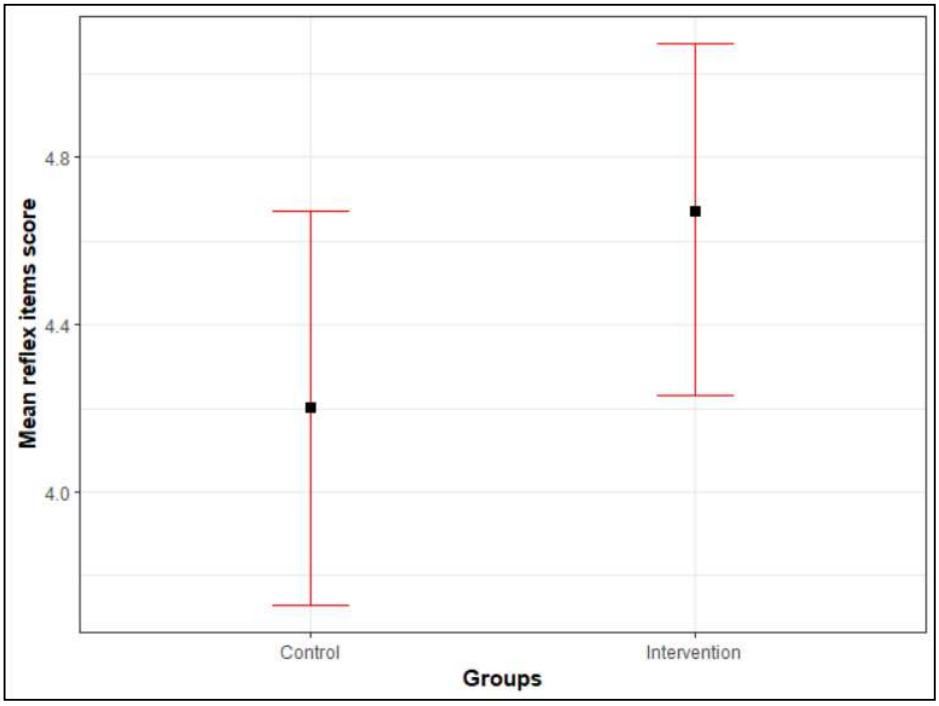


Figure 18: Mean plot of reflex items over groups.

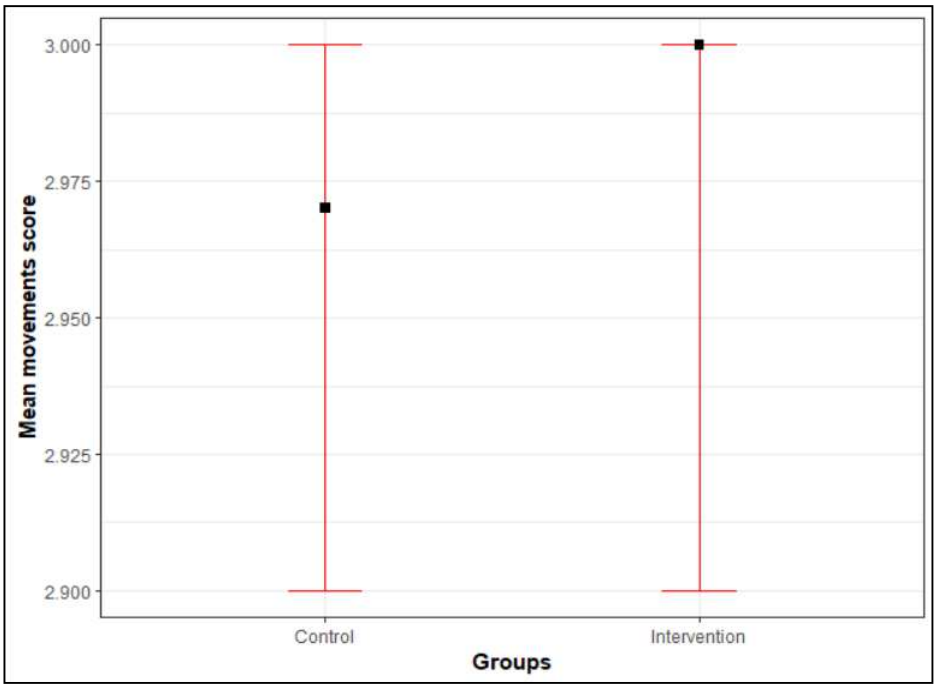


Figure 19: Mean plot of movements over groups.

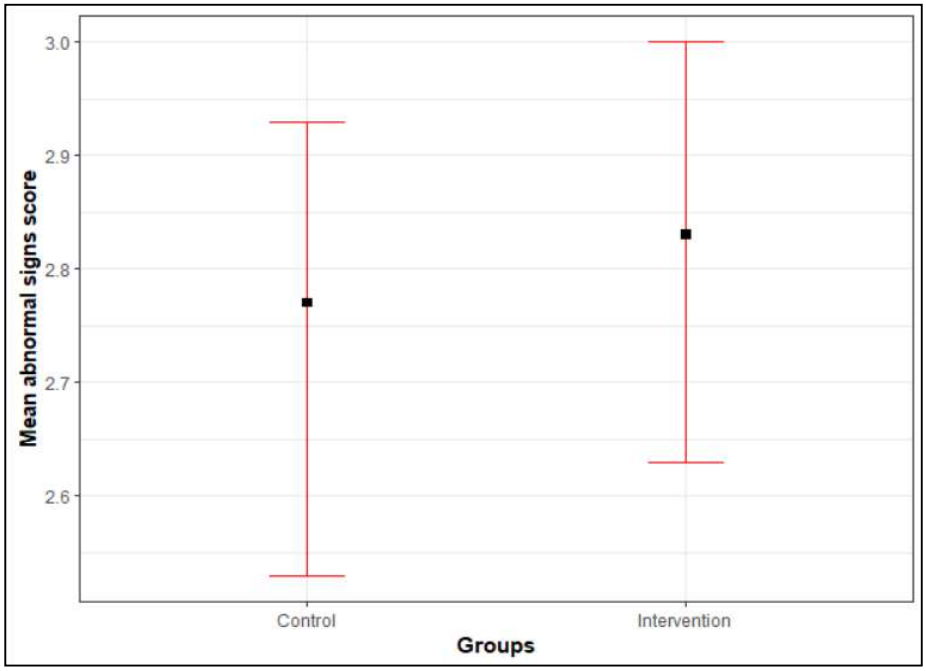


Figure 20: Mean plot of abnormal signs over groups.

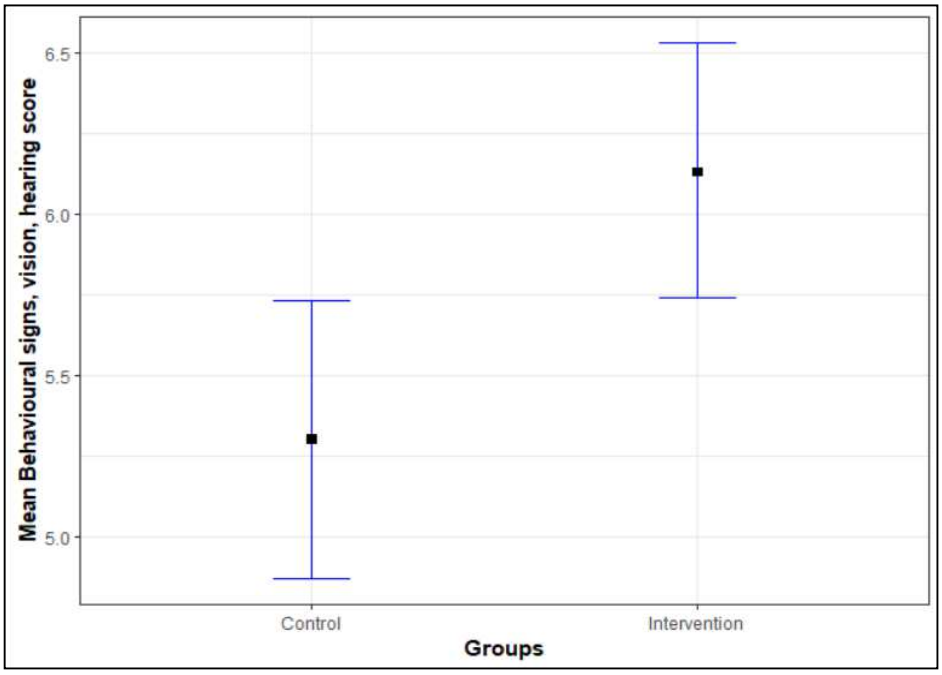


Figure 21: Mean plot of behavioural signs, vision, hearing over groups.

The following table gives the comparison of sub components of HINE score over groups.

Table 10: Comparison of sub components of HINE score over groups.

Variables		Group		Total (n=60)	p-value
		Control (n=30)	Intervention (n=30)		
HINE	Cranial Nerve function	13 ± 1.84 13.5 (8, 15)	14.43 ± 0.86 15 (12, 15)	13.72 ± 1.6 14 (8, 15)	**< 0.001MW***
	Posture	12.53 ± 2.3 12 (7, 16)	14.73 ± 2.85 16 (5, 18)	13.63 ± 2.8 14 (5, 18)	**< 0.001MW***
	Movements	5.07 ± 0.83 5 (3, 6)	5.33 ± 0.8 6 (4, 6)	5.2 ± 0.82 5 (3, 6)	0.1932MW
	Tone	20.4 ± 2.01 21 (16, 24)	22.5 ± 2.05 23 (15, 24)	21.45 ± 2.27 22 (15, 24)	**< 0.001MW***
	Reflexes and reactions	8.93 ± 1.46 9 (6, 12)	10 ± 2.07 10.5 (3, 12)	9.47 ± 1.85 9 (3, 12)	**0.0055MW***

*Abbreviation: MW – Mann Whitney U test, * indicates statistical significance.*

From Mann Whitney U test, it is observed that, there is significant difference in the distribution of Cranial Nerve function, Posture, Tone and Reflexes and reactions scores over groups. There is no significant difference in the distribution of movement score over groups.

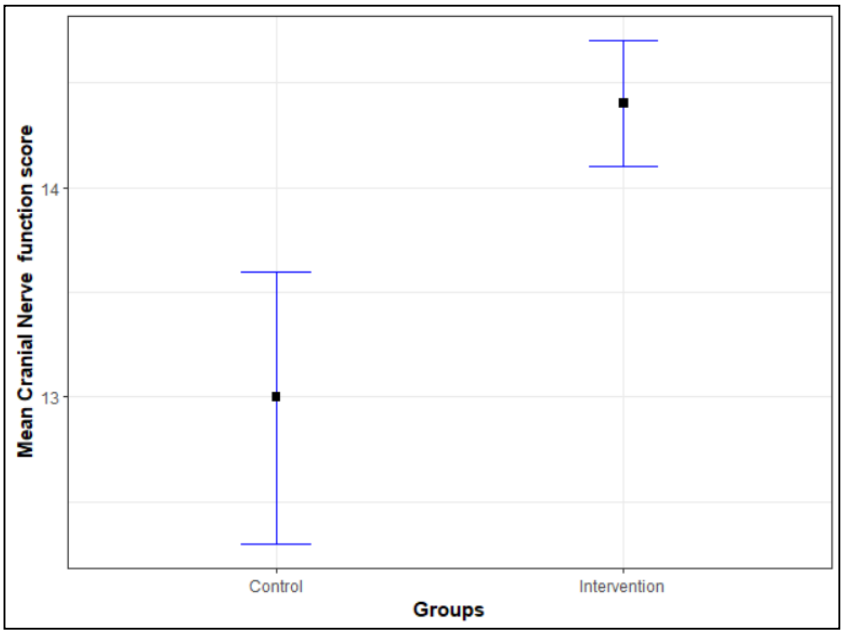


Figure 22: Mean plot of cranial nerve function over groups.

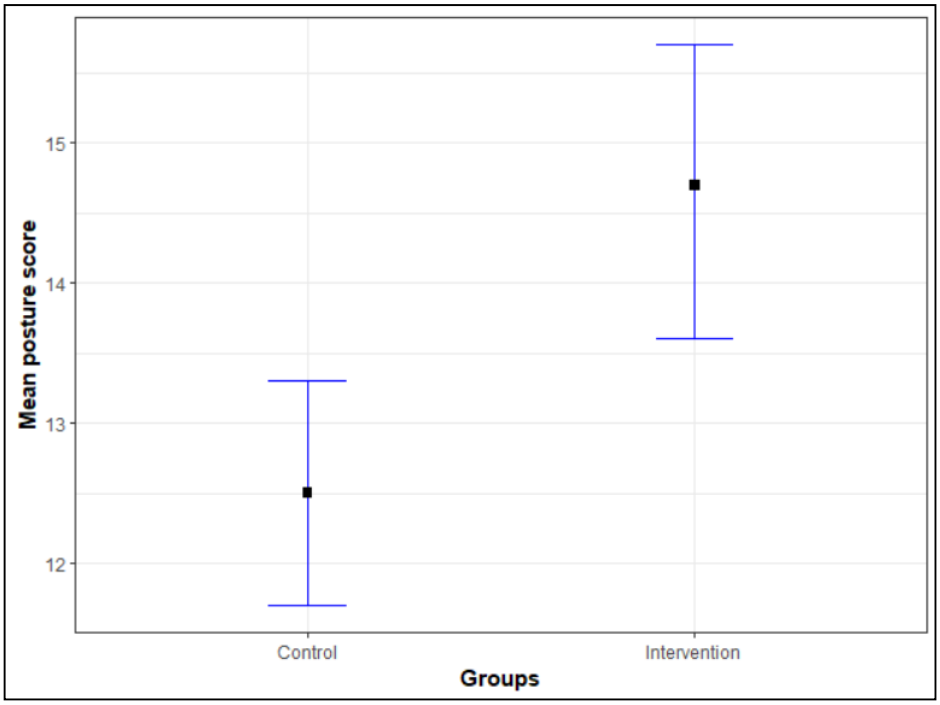


Figure 23: Mean plot of posture over groups.

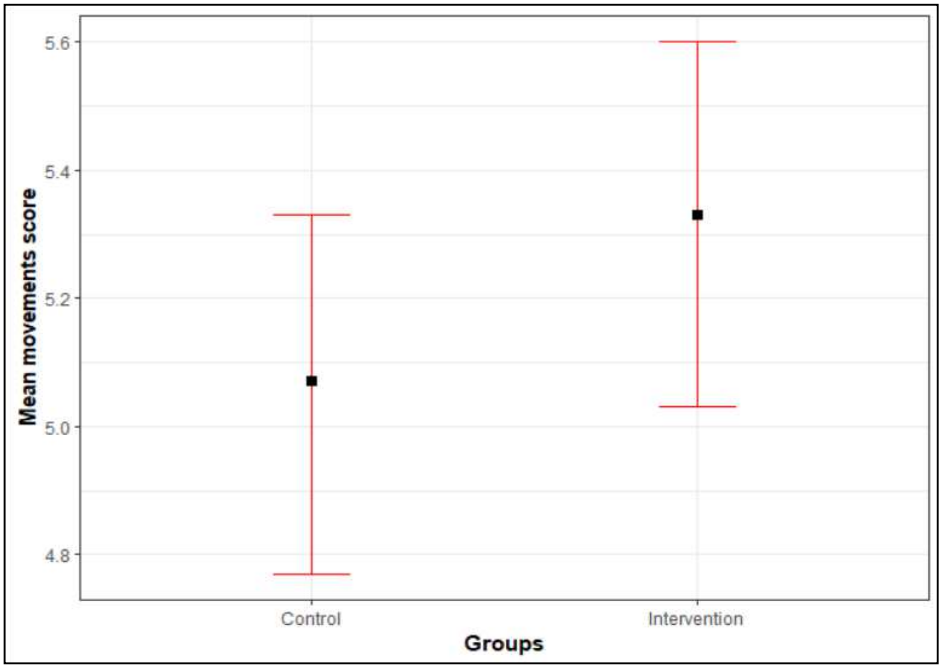


Figure 24: Mean plot of movements over groups.

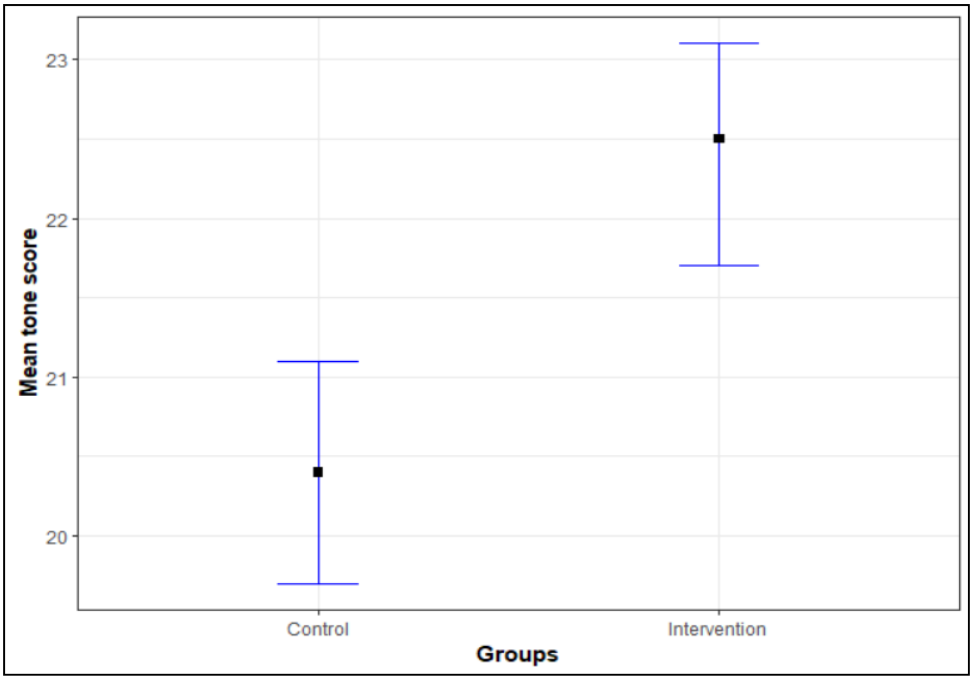


Figure 25: Mean plot of tone over groups.

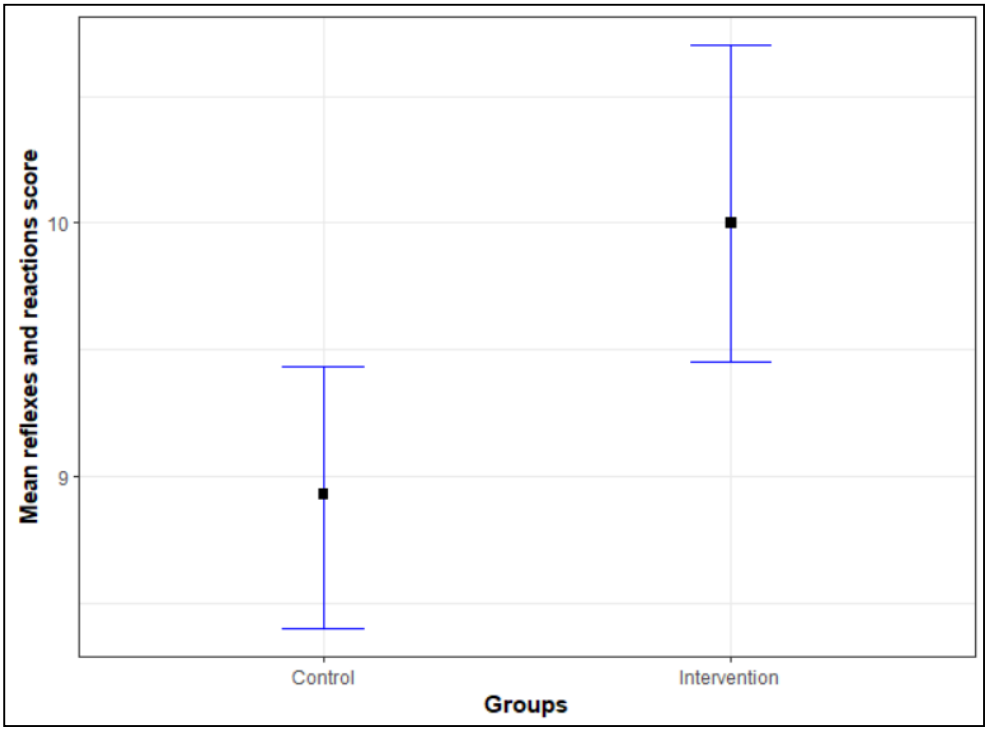


Figure 26: Mean plot of reflexes and reactions over groups.

The following table gives the comparison of weight over time points and groups.

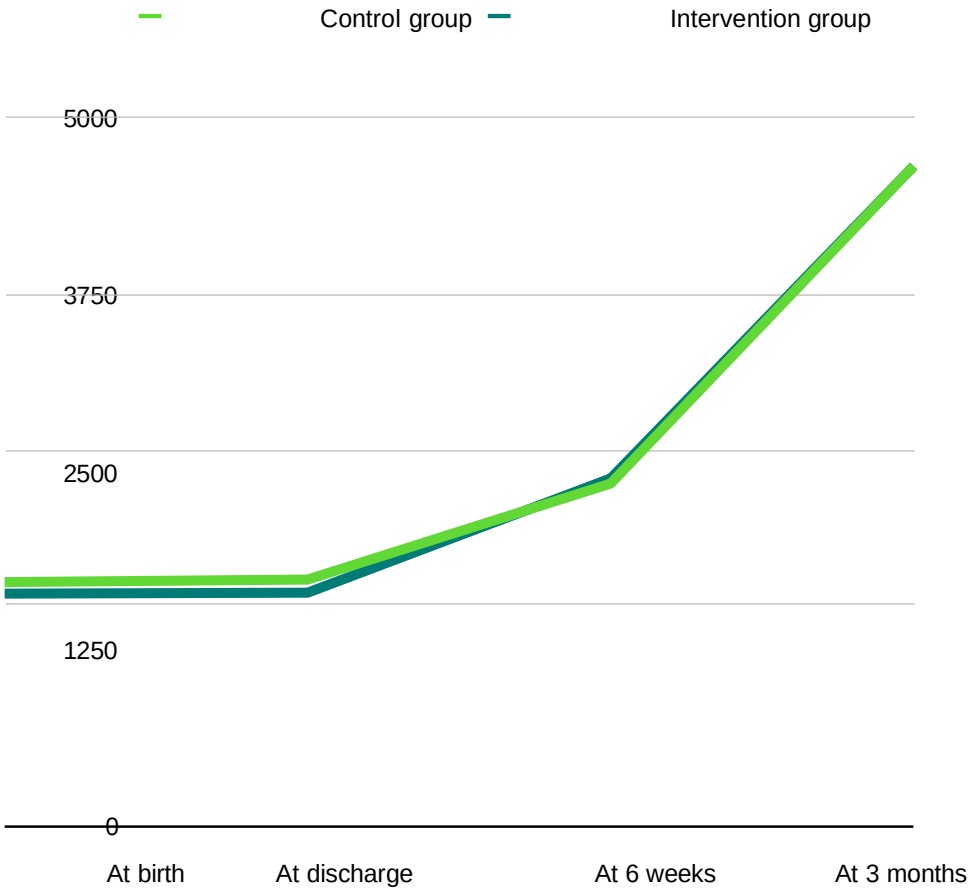
Table 11: Comparison of weight over time points and groups.

Time points	Group		Total	p-value
	Control	Intervention		
At Birth	1440.63 ± 291.38 1435 (914, 2000)	1405.8 ± 410.36 1340 (671, 2300)	1423.22 ± 353.29 1400 (671, 2300)	0.706[t]
At Discharge	1478.33 ± 256.35 1455 (1030, 2140)	1457.5 ± 274.08 1350 (1100, 2270)	1467.92 ± 263.32 1410 (1030, 2270)	0.4916[MW]
At 6 weeks	2227.33 ± 386.24 2230 (1500, 3240)	2313.33 ± 453.9 2270 (1600, 3860)	2270.33 ± 420.08 2230 (1500, 3860)	0.5297[MW]
At 3 months	4586.67 ± 711.48 4790 (3060, 5850)	4808.67 ± 710.98 4790 (3600, 6100)	4697.67 ± 714 4790 (3060, 6100)	0.2316[t]
p-value	**< 0.001[F]***	**< 0.001[F]***	-	-

*Abbreviation: t – Two sample t test, MW – Mann Whitney U test, F – Friedman test, * indicates statistical significance.*

From two sample t test, it is observed that, there is no significant difference in the mean weight over groups at birth and at 3rd month. From Mann Whitney U test, there is no significant difference in the distribution of weight over groups at discharge at 6th week and at 3 months.

Figure 27: Mean plot of weight over time points and groups.



The following table gives the comparison of OFC over time points and groups.

Table 12: Comparison of OFC over time points and groups.

Time points	Group		Total	p-value
	Control	Intervention		
At Birth	28.48 ± 1.88 29 (23, 32)	28.42 ± 2.35 29 (23, 32)	28.45 ± 2.11 29 (23, 32)	0.9038[t]
At Discharge	29.6 ± 1.52 29 (27, 34)	29.8 ± 1.43 30 (26, 32)	29.7 ± 1.47 29.5 (26, 34)	0.3355[t]
At 6 weeks	32.84 ± 1.74 33 (29, 36)	32.97 ± 1.47 33 (30, 36.5)	32.91 ± 1.59 33 (29, 36.5)	0.7674[t]
At 3 months	37.84 ± 1.46 38 (32.5, 41)	38.67 ± 1.36 38.5 (36, 42)	38.26 ± 1.46 38 (32.5, 42)	**0.0214[MW*]**
p-value	**< 0.001[F*]**	**< 0.001[F*]**	-	-

*Abbreviation: t – Two sample t test, MW – Mann Whitney U test, F – Friedman test, * indicates statistical significance.*

From two sample t test, it is observed that, there is no significant difference in the mean OFC over groups at birth, at discharge and at 6th week. From Mann Whitney U test, it is observed that, there is significant difference in the distribution of OFC over groups at 3 months of corrected gestational age.

Figure 28: Mean plot of OFC over time points and groups.

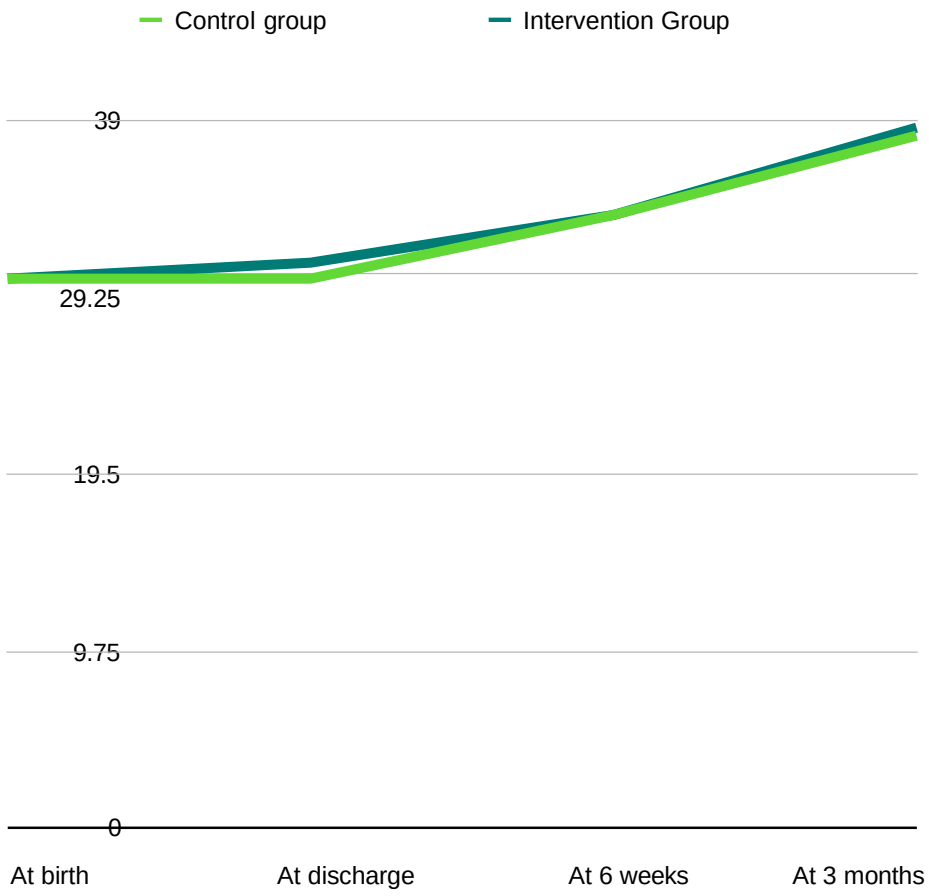


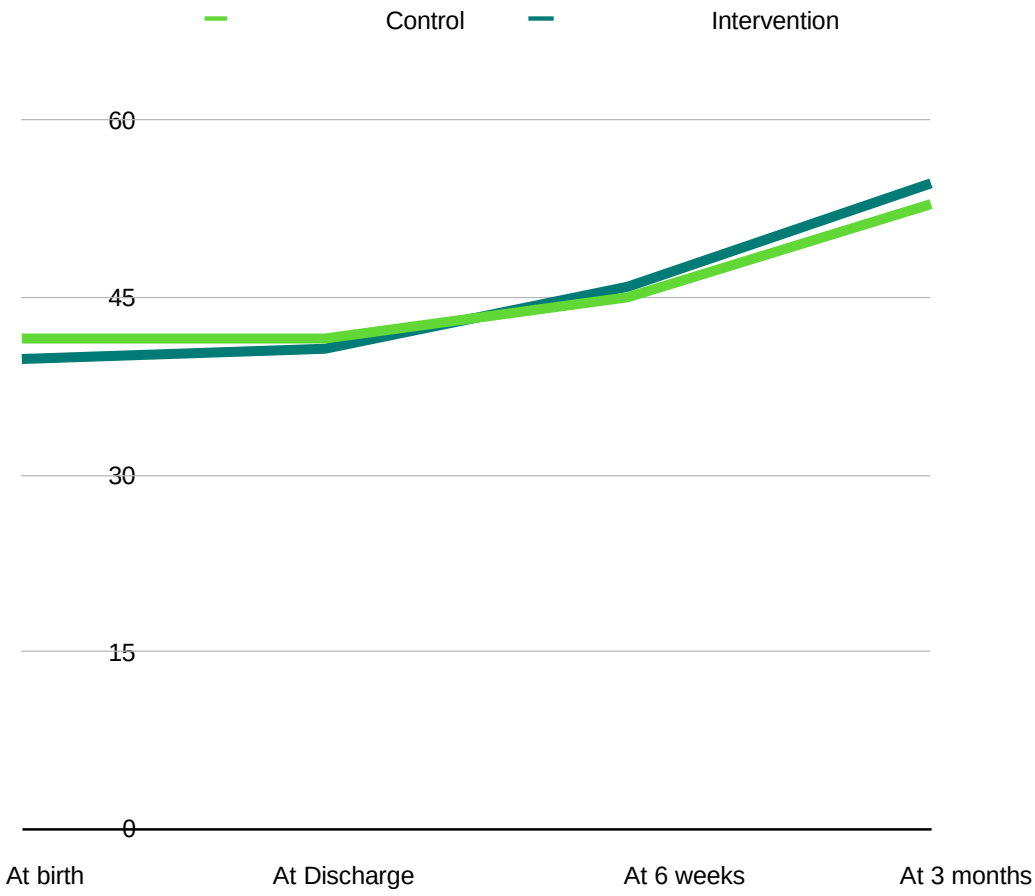
Table 13: Comparison of length over time points and groups.

Time points	Group		Total	p-value
	Control	Intervention		
At Birth	40.1 ± 3.18 40 (35, 49)	39.67 ± 4.06 39 (30, 46)	39.88 ± 3.62 40 (30, 49)	0.6495[t]
At Discharge	41.45 ± 2.81 41 (37, 49)	41 ± 3.13 40 (34, 46)	41.23 ± 2.96 41 (34, 49)	0.5604[t]
At 6 weeks	44.6 ± 2.93 45 (40, 50)	45.43 ± 2.86 46 (39, 53)	45.02 ± 2.9 45 (39, 53)	0.2697[t]
At 3 months	53.72 ± 2.89 54 (48, 59)	55.33 ± 2.85 56 (50, 61)	54.52 ± 2.96 55 (48, 61)	**0.0334[t*]**
p-value	**< 0.001[F*]**	**< 0.001[F*]**	-	-

Abbreviation: t – Two sample t test, F – Friedman test, * indicates statistical significance.

From two sample t test, it is observed that, there is significant difference in the mean length over groups at 3 months of corrected gestational age. However, there is no significant difference in the mean length over groups at any other timepoints.

Figure 29: Mean plot of length over time points and groups.



The following table gives the comparison of length, weight and OFC over mother's education in control group.

Table 14: Comparison of length, weight and OFC over mother's education in control group.

Variables	Time points	Mother's education			p-value
		SSLC and less	PUC	Graduate and more	
Weight	At Birth	1400 ± 188.68 1360 (1240, 1860)	1408.33 ± 227.46 1480 (990, 1630)	1477.93 ± 366.13 1500 (914, 2000)	0.5119[K]
	At discharge	1445.56 ± 129.05 1480 (1220, 1610)	1570 ± 359.67 1455 (1130, 2140)	1461.33 ± 275.34 1420 (1030, 1880)	0.629[A]
	At 6 weeks	2221.11 ± 177.65 2240 (1900, 2410)	2313.33 ± 457.59 2290 (1560, 2800)	2196.67 ± 460.43 2220 (1500, 3240)	0.831[A]
	At 3 months	4306.67 ± 622.43 4420 (3320, 5150)	4786.67 ± 426.83 4790 (4100, 5340)	4674.67 ± 828.41 4800 (3060, 5850)	0.363[A]
OFC	At Birth	28 ± 1.41 28 (26, 30)	29.17 ± 1.72 29 (27, 32)	28.5 ± 2.18 29 (23, 32)	0.515[A]
	At discharge	28.94 ± 0.77 29 (28, 30)	30.67 ± 1.75 30 (29, 34)	29.57 ± 1.61 29 (27, 33)	0.0959[A]
	At 6 weeks	32.06 ± 1.7 33 (29, 34)	33.67 ± 2.07 34 (30, 36)	32.99 ± 1.53 33 (30.5, 36)	0.195[A]
	At 3 months	36.67 ± 1.7 37 (32.5, 38)	38.58 ± 1.43 38 (37, 41)	38.25 ± 0.86 38 (37, 40)	**0.0097[K]***
Length	At Birth	39.78 ± 1.2 40 (38, 42)	40.5 ± 3.78 41 (35, 46)	40.13 ± 3.85 41 (35, 49)	0.915[A]
	At discharge	41.06 ± 1.33 41 (40, 44)	42.5 ± 2.66 42.5 (39, 47)	41.27 ± 3.5 41 (37, 49)	0.6042[K]
	At 6 weeks	43.89 ± 2.2 44 (41, 48)	45.33 ± 1.97 45.5 (42, 48)	44.73 ± 3.61 45 (40, 50)	0.642[A]
	At 3 months	52.61 ± 2.18 54 (49, 55)	53.5 ± 3.08 54.5 (48, 56)	54.47 ± 3.14 55 (48, 59)	0.1638[K]

*Abbreviation: A – One-way ANOVA, K – Kruskal Wallis test, * indicates statistical significance.*

From Kruskal Wallis test, it is observed that, there is significant difference in the distribution of OFC at 3 months over mother's education in control group.

Further, from post hoc analysis, it is observed that, there is significant difference in the distribution of OFC of the baby whose mother's education level is SSLC and less with the OFC of the baby whose mother's education level PUC (p-value = 0.014) and graduate and above (p-value=0.033) in 3 months.

From Kruskal Wallis test and one-way ANOVA, it is observed that, there is no significant difference in distribution of weight and length at birth, at discharge , at 6 weeks and 3 months of corrected gestational age over mother's education.

The following table gives the comparison of length, weight and OFC over mother's education in intervention group.

Table 15: Comparison of length, weight and OFC over mother's education in intervention group.

Variables	Time points	Mother's education			p-value
		SSLC and less	PUC	Graduate and more	
Weight	At Birth	1760 ± 402.99 1800 (1240, 2200)	1217.5 475.98 1180 (680, 1830)	1375.64 ± 381.29 1340 (671, 2300)	0.139[A]
	At discharge	1692.5 ± 209.66 1780 (1380, 1830)	1347.5 ± 226.48 1260 (1190, 1680)	1434.77 ± 277.07 1342.5 (1100, 2270)	0.063[K]
	At 6 weeks	2450 ± 222.41 2540 (2120, 2600)	2140 ± 84.85 2150 (2040, 2220)	2320 ± 516.8 2380 (1600, 3860)	0.4205[K]
	At 3 months	5265 ± 523.93 5190 (4800, 5880)	4647.5 ± 825.73 4315 (4100, 5860)	4755 ± 716.8 4660 (3600, 6100)	0.385[A]
OFC	At Birth	28.5 ± 1.29 28.5 (27, 30)	27.5 ± 3.11 28.5 (23, 30)	28.57 ± 2.41 29 (24, 32)	0.717[A]
	At discharge	29.62 ± 1.11 29.5 (28.5, 31)	29.25 ± 2.5 29.5 (26, 32)	29.93 ± 1.29 30 (28, 32)	0.673[A]
	At 6 weeks	32.5 ± 1 32 (32, 34)	32.62 ± 1.31 32.5 (31.5, 34)	33.11 ± 1.58 33 (30, 36.5)	0.6472[K]
	At 3 months	39 ± 1.41 38.5 (38, 41)	38.12 ± 0.85 38.25 (37, 39)	38.71 ± 1.44 38.5 (36, 42)	0.7518[K]
Length	At Birth	41 ± 3.37 39.5 (39, 46)	37.25 ± 6.13 37 (30, 45)	39.87 ± 3.78 39.5 (32.5, 45)	0.3257[K]
	At discharge	41.5 ± 3.11 40.5 (39, 46)	39 ± 4.55 38.5 (34, 45)	41.27 ± 2.88 40 (37, 46)	0.4[A]
	At 6 weeks	47 ± 1.15 47 (46, 48)	44.5 ± 1 44 (44, 46)	45.32 ± 3.21 45.5 (39, 53)	0.2827[K]
	At 3 months	56.5 ± 2.08 56.5 (54, 59)	53.5 ± 2.08 53.5 (51, 56)	55.45 ± 3.02 56 (50, 61)	0.318[A]

Abbreviation: K – Kruskal Wallis test, A – One-way ANOVA.

From Kruskal Wallis and one-way ANOVA test, it is observed that, there is no significant difference in the distribution of weight, OFC and length at birth, at discharge, at 6 weeks and 3 months of corrected gestational age over mother's education at any time point in intervention group.

Note: Mother's education is clubbed into 3 categories as many of the original categories had only one subject in it.

DISCUSSION

It had been well argued that infants in Neonatal ICUs are subject both to a highly stressful environment - continuous, high-intensity noise and bright light (Field 1990)[11,102,148] and also to a lack of the tactile stimulation that they would otherwise experience in the womb or in general mothering care (Montagu 1978).

In utero, due to amniotic fluid infants are exposed to physical stimulation, this raises the question whether gentle physical massage can help babies born before 37 weeks gestation or weighing less than 2500 grams to grow and develop after birth, and if it can improve their neurological developmental outcome.

A number of workers have suggested that massage both decreases stress and provides tactile stimulation (Vickers 1996).[164] Hence massage has been recommended as an early intervention to promote growth and near development of preterm and low birth weight infants.

Though massage could be defined as any form of systematic tactile stimulation by human hands, the type of massage typically used for neonatal care is a gentle, slow stroking of each part of the body in turn. For example, Scafidi[11,133,148] in 1993 describes massage as the infant being placed in a prone position and being stroked “for 1 min periods (12 strokes at approximately 5 seconds per stroking motion) over each region of the body.

Massage is often combined with other forms of stimulation such as kinaesthetic stimulation (eg. passive extension/flexion movements of the arms and legs) and vestibular or auditory stimulation.

In our study preterm infants who were born at <34 weeks of period of gestation were given tactile and kinaesthetic stimulation.

Infants who met the eligibility criteria were enrolled into the study after obtaining written informed consent from parents and randomised in 1:1 ratio to one of the following two study groups: therapeutic massage supplementation (intervention group) or control group.

Sample size of our study was 60 randomised into intervention group and control group comprising of 30 neonates in each which is comparable with other previous studies.

Most of the studies done to evaluate for effect of massage intervention on growth and development in preterm neonates had small sample size and were conducted at single centre.[91,133,134,165,172]

Our protocol included tactile stimulation followed by kinaesthetic stimulation followed by tactile stimulation again, and similar exercise was repeated twice a day . Massage intervention was taught to the mother before baby's discharge from the NICU and thus massage was provided by the mother at home for 6 weeks or till corrected gestational age of 40 weeks whichever is later.

Only a few drops of oil was used for giving massage just for the purpose of reducing friction, our study was not aimed at studying the benefits of oil massage.

Tactile and Kinaesthetic stimulation taught to the mother of babies included in intervention group on a mannequin for 1 day and from next day mother was taught the same on her baby.

Mothers were advised to continue practicing massage technique on her baby for 2 days until she was confident. Once the mother was confident and baby being discharged, mothers continued doing therapeutic massage for 6 weeks or upto 40 weeks of corrected gestational age, whichever is later.

After discharge, video and/or pictorial description of the techniques were shared with the mother and followed up regularly about any difficulties and comprehension with the therapeutic massage through phone calls and messages and at the time of follow up visits at high risk clinic.

Our research study is different from other previous studies in the sense that massage was provided by mothers after discharge at home. In contrast, all earlier studies involved patients who received therapeutic intervention from nurses, physiotherapists, or other professionals.

All previous research studies have only examined the advantages of interventions during hospital/ NICU stays and their effects on growth and development.

Our study is unique from others since massage was given by mothers and at home, decreasing the need for hospitalisation and the associated financial burden.

It has been usually reported that nutrition pattern, gender, prenatal and postnatal care, birth weight, and type of maternal relationship affect neonate's growth and development (Dorea, 2012). For instance, it has been reported that besides its calming effects, touching may improve growth and development of neonates (Ahmed et al.,2015).

Additionally in our study it was also observed that, there is no significant difference in the distribution of mother's education status over groups , distribution of mode of delivery, obstetric score, mechanical ventilation/CPAP and major problems at discharge over groups.

Unlike our study in-depth discussion of maternal education and its correlation with neonatal growth and neurodevelopment has not been formerly.

Out of the 60 enrolled patients, 26 (43.33%) were born to Multigravida whereas 34 (56.67%) were born to Primigravida.

It was found that 11 (18.33%), 40 (66.67%), 9 (15%) belonged to upper, middle and lower caste respectively in both groups. 53 (88.33%) were delivered via LSCS while 7 (11.67%) were delivered via NVD.

Out of the total enrolled cases ie 50% required mechanical ventilation.About 70 % neonates had no problem at discharge while 30% had various problems at discharge , sepsis being the major constituent.

Mean gestational age at birth in control group was 31.96 ± 1.76 weeks while in intervention group it was 31.63 ± 2.44 weeks. There was not significant difference in comparators.

While the control group has 6(20%) and 24(80%) females and male, intervention group had 8(26.66%) and 22(73.33%) males and females respectively.

Mean duration of hospital stay was 22.15 ± 13.98 days ; 17 (5, 56) and the difference between both the groups was insignificant.

Preterm babies follow altered neuro-developmental trajectory when compared to their term peers as a result of early birth , and the altered environment.

Methods of neurodevelopmental assessment of the preterm infant includes a number of clinical examinations used to evaluate neurological function and neurobehaviour . Most commonly used in the neonatal period include the Prechtl's General Movements Assessment (GMA), Hammersmith Neonatal Neurological Examination (HNNE), Amiel-Tison Neurological Assessment at term, Neonatal Behavioural Assessment Scale (NBAS), Neurobehavioural Assessment of the Preterm Infant (NAPI) and the Neonatal intensive care unit Network Neurobehavioural Scale (NNNS).

These assessments vary in the sense of time required for training, as well as in the appropriate age of administration and their scoring systems.[172]

Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III) is a structured instrument to assess cognitive and social emotional development, language and motor abilities and is the most widely used to assess neurodevelopment of preterm and very low birth weight infants in the first three years. In a recent review, Mental Development Index (MDI) scores were strongly predictive of later cognitive functioning.[91]

There is however, limited current evidence of improved neurodevelopment.

According to a study by Renato S. Procianoy, Eliane W. Mendes a, Rita C. Silveira in 2009 to assess the effect of massage therapy on neurodevelopment of very low birth weight infants at two years corrected age . Newborns with birth weight between ≥750 and ≤1500 g and gestational age ≤32 weeks were randomly assigned to massage therapy by mothers plus skin-to-skin care (Intervention Group) or just skin-to-skin care (Control Group) during their hospital stay.

It was found that growth at 2 years corrected age was similar in both groups , however intervention group had borderline higher Psychomotor Development Index (PDI) and significantly higher Mental Development Index (MDI) scores than control group.[165]Feldman et al. studied 73 preterm infants who received skin-to-skin care in the NICU matched with 73 control infants who received standard incubator care. At 6 months, the MDI and the PDI were higher in skin-to-skin cared infants than in controls.[166]

Nelson et al. evaluated 37 infants at one year corrected age with severe CNS injury or extreme prematurity randomly assigned to multi-sensory intervention or control group. Although the trend was suggestive of beneficial effect of the intervention, there were no differences between both groups in Bayley scores.[167]

The aim of our study was to investigate the effects of infant massage performed by the mother in very preterm babies for their neurological outcomes and to detect and strategise for early and effective intervention.

In our study the patients were evaluated at 40 weeks and 3 months of corrected age for their neurodevelopment outcome using HNNE (Hammersmith Neonatal Neurological Examination) and HINE (Hammersmith Infant Neurological Examination) scales respectively at follow up at High-Risk Baby Clinic at KAHER's Dr. Prabhakar Kore Hospital, Belagavi for both the groups.

Previous studies had long term follow up evaluation for neonates for neurodevelopment, between 6 months to 2 years, thus making it difficult to follow up for evaluation hence compromising/ affecting the results. Our study was different from others as neurological development and growth assessment was done at 40 weeks and 3 months of corrected age

HNNE performed at two weeks post-term in term infants, or at term-corrected age in preterm infants, is highly predictive of a neuro-developmental deficit.

In accordance with a recent study by Venkata et al. in 2020 the HNNE exhibited the same predictive value for predicting CP at one year when administered early (i.e., before discharge in preterm children) and when performed at the recommended age. HNNE had a sensitivity of 50–64% and specificity of 73–77% with a global optimality score cut-off of 32.5, as per Dubowitz.[176-177]

In our study mean HNNE score was 28 ± 2.52 for control group while it was 30.1 ± 2.83 for the intervention group, there was statistically significant difference between the two groups.

Further subcomponents of HNNE were compared between the two groups and it was observed that, there is significant difference in the distribution of posture and behavioural signs, vision, hearing scores over groups however there is no significant difference in the distribution of tone pattern, reflex items, movement and abnormal signs scores over groups.

Infants in the intervention group displayed superior head control, enhanced visual orientation, and alertness when the HNNE scoring was examined in greater detail.

It was found that mothers who massaged their infants had lower levels of irritability because there was a stronger relationship and bonding between them.

The HNNE examination was performed at the corrected gestational age of 40 weeks at a follow-up visit to the High Risk Baby Clinic at KLE Hospital. However, because the newborns were assessed after their ROP screening, the visual orientation test suffered, but this was common confounding factor for both groups.

Mean HINE score at corrected gestational age of 3 months was 59.93 ± 6.67 for control group while it was 67 ± 6.73 for the intervention group, difference was statistically significant between the two groups.

Using HINE scoring specific cut-off scores for predicting cerebral palsy both in pre-term and full- term infants have been published. The HINE has good sensitivity and a high predictive value for risk of cerebral palsy in high-risk populations under 5 months.

A HINE score<57 at 3months 96%predictive of cerebral palsy (sensitivity 96%; specificity 87%) In our study, 8 babies in control had a global HINE score of <57 whereas only 1 baby in intervention group had global HINE score <57.

Mothers of all these babies who had global score of <57 were counselled about the high predictive risk of cerebral palsy and referred for multidisciplinary care involving physiotherapist, paediatric psychiatrist, paediatric neurologist, ophthalmologist and speech therapist.

There are three parts to the HINE: a neurological examination (which is scored), developmental milestones and behaviour (which are not scored) and comprises of 26 items divided into 5 domains, assessing cranial nerve function, posture, quality and quantity of movements, muscle tone, and reflexes and reactions . Each item is scored individually (0, 1, 2 or 3). The maximum score for any one item is a score of 3 and the minimum is a score of 0.Higher scores indicates better neurological performance. The maximum global score is 78.[170,171]

While comparing the subcomponents of HINE scoring it was observed that, there was significant difference in the distribution of Cranial Nerve function, Posture, Tone and Reflexes and reactions scores over groups but there is no significant difference in the distribution of movement score over groups.

When analysing HNNE scoring subgroups, it was shown that the intervention group's visual response was superior. Intervention group babies getting assistance had better posture and tone. There was no or very little head lag when being pulled to sit, and the trunk was better in the sitting posture.

Tendon reflexes were normal as compared to brisk in control group.

Infant massage in the preterm infant has also shown to have positive effects on weight gain and reduced length of stay in hospital settings.

Many studies have indicated the positive effects of massage therapy on neonatal growth and development (Kelmanson et al.,2006; Procianoy et al.,2010)[150,] weight (Kulkarni et al.,2010; Procianoy et al.,2010)[14], and behaviours (Scafidi & Field, 1996)[133,134]

Many non-systematic reviews have been published which support massage interventions in the newborn care of preterm/LBW infants (Field)[133,148-150].

The only systematic review published is that by Ottenbacher[78] who has concluded that 'subjects receiving some form of controlled tactile stimulation performed better on a variety of dependent measures like growth and development than subjects who have not been receiving intervention'. However this review is not that relevant now and is flawed by the inclusion of trials of varying quality which evaluated varying interventions (from massage to non-nutritive sucking).

In our study, 60 subjects, all born at less than 34 weeks of period of gestation, were enrolled on the basis of inclusion and exclusion criteria and randomly categorised into two groups - intervention group and the control group.

Anthropometric measures such as weight, head circumference and length were compared between the two groups at birth, at the time of enrolment ie discharge, at corrected gestational age of 40 weeks and corrected gestational age of 3 months.

As per our research study the mean weight at corrected gestational age of 3 months for the control group was (4586.67 ± 711.48) g while for the intervention group it was (4808.67 ± 710.98) g.

It was observed that, there was no significant difference in the mean weight over groups at birth and at corrected gestational age of 40 weeks and at 3 months of corrected gestational age.

This finding was not in concordance with other studies, for example, according to Vickers A, Ohlsson A et al. - Massage for promoting growth and development of preterm and/or low birth- weight infants, Cochrane Database of Systematic Reviews 2004, preterm/LBW infants who were receiving massage interventions gained more weight per day than controls (weighted mean difference (WMD) 5.1g, 95% CI 3.5, 6.7), however this difference is of low clinical significance.[164]

Also according to Dieter et al. (2003), preterm neonates with mean Gestational age 31 weeks and LBW randomised into two groups and massage was performed by massage therapists for 15 minutes, 3 times a day for 5 days and found that babies in massage group gained more weight.

Daily weight gain: 243.5 (184.5) and 113.5 (60.7) in intervention group vs control group respectively.[149,163]

Our study also differed from other studies like a study by Massaro, Hammad, Jazzo and Aly (2009) which included preterm neonates </= 32-week POG, kinaesthetic stimulation was given by nurses trained in massage, unlike our study where mothers were the massage provider, for 15 minutes twice a day from recruitment to discharge. Results were as follows, total weight gain: 2298 ± 82 and 2176 ±88, Head circumference: 31 ± 0.4 and 30 ± 0.4, Length: 44 ± 0.7 and 43±0.6 .

Premature babies who received massage therapy with kinaesthetic stimulation gained more weight, however there was no effect on head circumference and length.

In a RCT by Kumar, Upadhyay, Dwivedi et al. in 2013 neonates <35 weeks GA and <1800g were enrolled and massage was performed for 10 minutes, 4 times a day. During massage, equal amount of sunflower oil was used.

Total weight gain: 1.946.2 (252.1) and 1.773.2 (217.1) Length: 43.6 (2.9) and 43.9 (2.9)

Head circumference: 31.9 (1.7) and 31.3 (1.5) . It was reported that low birth-weight premature babies gained more weight.[149,155]

Our study was in contrast to a study done by Akhavan Karbasi S, Golestan M et al in July 2013 where 17 girls and 23 boys with mean gestational age of 34.4±1.22 weeks were evaluated and in the body massage group, only weight at the age of two months was significantly higher than the control group (mean±SD: 3250±305 vs. 2948±121 gr, p=0.005)[174]

In our study the mean OFC at corrected gestational age of 3 months for the control group was (37.84 ± 1.46) cm while for the intervention group it was (38.67 ± 1.36) cm also, it was observed that there was significant difference in the distribution of OFC over groups at corrected gestational age of 3 months.

This result was in correlation with a study done by Erçelik ZE, Doğan P et al between 2000-2020 where total of 308 premature babies were included in this systematic review and meta- analysis and found that the head circumference (MD: 0.97, 95% CI: min: 0.73, max: 1.21, P < .001) of the babies in the massage group are statistically significantly higher than the infants in the control group.[173]

However it was in contrast to a study done by Dwivedi et al in 2013 where neonates <35 weeks GA and <1800g were enrolled and massage was performed for 10 minutes , 4 times a day.

Difference in head circumference: 31.9 (1.7) and 31.3 (1.5) was not statistically significant and was stated that massage intervention had no effect on head circumference.[149,155]

In our study it was found that here was significant difference in the mean length over groups at 3 months of corrected gestational age. The mean length of infants at corrected gestational age of 3 months for the control group was 53.72 ± 2.89 while for the intervention group it was 55.33 ± 2.85. Also it was observed that, there was significant difference in the distribution of length over timepoints in both groups.

This finding was on contrast to most of the previous studies carried so far. Also it holds true with other study done by Priyadarshi M, Kumar et al in October 2018 where meta-analyses suggested that whole-body massage may increase infant length at the end of the intervention period (median assessment age 6 weeks; mean difference (MD) = 1.6 cm.

Hence our study was comparable to other studies in the term that there was weight gain over various timepoints in both groups however no significant difference was seen at the corrected gestational age of 3 months.

However it differs from most of the other previous studies because our study showed significant difference in length and OFC over the timepoints and at the corrected gestational age of 3 months.

Our study showed significant relation between massage and growth that's gain of OFC and length. However relation between massage and weight gain was not significant.

Therapeutic touch in form of skin to skin contact, massage, etc has been emphasised by healthcare professionals for improvement of neonates' growth and development. However, still lot of inconsistencies exist regarding effects and methods of massage in neonates.

The purpose of our clinical trial was to assess and comprise intervention regarding the effects of tactile-kinaesthetic stimulation by mothers on growth indices and neurodevelopment of preterm infants.

Through our study we were able to detect infants at risk of delayed neurodevelopment at 40 weeks of age and thus were able to follow up them until 3 months of corrected gestational age to compare HINE global score and predict risk of cerebral palsy in high risk populations

CONCLUSION

Despite having few or no medical issues at the time of birth, preterm very low birth weight infants are at a significant risk of experiencing neurodevelopmental delay. Such infants' care and therapies have an effect on preexisting risk.

Our study was conducted with the objective to assess neuro-developmental and growth outcome of preterm infants born at <34 weeks of gestational age, who have received tactile and kinaesthetic stimulation. Therapeutic massage intervention in the form of tactile and kinaesthetic stimulation by the mothers at home in early preterm infants, born at <34 weeks POG, can have a positive impact on neurodevelopment and growth in future.

By doing HNNE and HINE, the optimal score obtained for HINE and HNNE showed a significant difference between two groups indicating therapeutic massage can help in better neurodevelopment outcome in the infant. Our study also showed significant difference in length and OFC at the corrected gestational age of 3 months in the neonates receiving therapeutic massage.

It is possible to train and involve mother to provide this therapeutic intervention at home efficiently

SUMMARY

- A Randomised controlled trial was conducted in Neonatal Intensive Care Unit and follow up clinic of the KAHER's Dr. Prabhakar Kore Hospital and MRC , Belagavi , Karnataka from Jan 2021 to December 2021.
- A total of 60 preterm infants born at <34 weeks of gestation who are haemodynamically stable and ready for discharge were included as a part of the research study, 30 in each intervention and control group.
- Massage intervention was taught to the mothers and provided by the mother itself and not a therapist, intervention was started at the time of discharge from NICU and continued upto 6 weeks or corrected gestational age of 40 weeks whichever is later.
- Our study differed form others, as it consisted of two sessions of tactile and kinaesthetic stimulation, each session comprising of tactile stimulation followed by kinaesthetic stimulation and again followed by tactile stimulation.
- The neonates were evaluated at 40 weeks and 3 months of corrected age for their growth and neurodevelopment outcome using HNNE (Hammersmith Neonatal Neurological Examination) and HINE (Hammersmith Infant Neurological Examination) scales.
- It was found that intervention group showed higher HNNE as well as HINE scores when compared with the control groups at corrected gestational age of 40 weeks and 3 months respectively.

- Mean HNNE score was 28 ± 2.52 for control group while it was 30.1 ± 2.83 for the intervention group, there was statistically significant difference between the two groups.
- Further subcomponents of HNNE were compared between the two groups and it was observed that, there is significant difference in the distribution of posture and behavioural signs, vision, hearing scores over groups however there is no significant difference in the distribution of tone pattern, reflex items, movement and abnormal signs scores over groups.
- Mean HINE score at corrected gestational age of 3 months was 59.93 ± 6.67 for control group while it was 67 ± 6.73 for the intervention group , difference was statistically significant between the two groups . Higher scores indicates better neurological performance.
- While comparing the subcomponents of HINE scoring it was observed that, there was significant difference in the distribution of Cranial Nerve function, Posture, Tone and Reflexes and reactions scores over groups but there is no significant difference in the distribution of movement score over groups.
- While it was found that there was statistically significant difference between the OFC and length over time points between the two groups, however no significant difference was observed in weight of the infant in comparator groups.
- The mean length of infants at corrected gestational age of 3 months for the control group was (53.72 ± 2.89) cm while for the intervention group it was (55.33 ± 2.85) cm.

- The mean OFC at corrected gestational age of 3 months for the control group was (37.84 ± 1.46) cm while for the intervention group it was (38.67 ± 1.36) cm.It was observed that, there is significant difference in the distribution of OFC over groups at 3 months of corrected gestational age.
- The mean weight at corrected gestational age of 3 months for the control group was (4586.67 ± 711.48) g while for the intervention group it was (4808.67 ± 710.98) g. It was observed that, there is no significant difference in the mean weight over groups at birth and at 3 months of corrected gestational age.
- In order to compare global scores and predict the likelihood of cerebral palsy in high risk populations, we were able to identify infants at risk of delayed neurodevelopment at 40 weeks of age through our study. We were then able to follow up with them until 3 months of corrected gestational age.

LIMITATIONS AND SCOPE OF THE STUDY

As the research study included limited population from a single centre , the results cannot be extrapolated to the whole population.

A study with large sample size from different geographical areas with different levels of NICU care should be conducted to have more reliable results.

It would be interesting to follow up these preterm babies up to early childhood and compare for neurological outcomes.

By doing HNNE and HINE scoring we were able detect risk of delayed neurological development, hence we were able to identify newborns at risk of delayed neurodevelopment at 40 weeks of age and monitor them until 3 months of corrected gestational age in order to compare global scores and identify groups at high risk for cerebral palsy

This provided us with evidence to include tactile and kinaesthetic stimulation as an effective early intervention technique for preterm infants which can be provided by the mothers at home.

Thus, we may advocate implementing the aforementioned intervention and provide suggestions for appropriate regular massage therapy of premature infants to the mothers.

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ANNEXURE I – CONSENT FORM

CONSENT FOR PARTICIPATION IN RESEARCH

"Effect of tactile and kinaesthetic stimulation on neuro-development and growth of preterm infants born at < 34 weeks gestational age – Randomised Controlled Trial Study".

Reg No. BM0120014

Principal Investigator :

Guide: Dr.

Co-Guide: Dr.

You are hereby requested to involve yourself and your baby in the above said research to be conducted at KLE'S Dr. PrabhakarKore Hospital and Medical Research Centre, Belagavi from January 2021 to December 2021 by Dr Prateek Mohan,Resident,Department of Paediatrics at Jawaharlal Nehru Medical College,Belagavi.

Introduction

Preterm infants are at high risk of developing neurodevelopment delay despite little or no medical complications at the time of birth.The care and intervention of such infants have an impact on pre-existing risk. There is evidence that therapeutic massage has beneficial effects on preterm infants in the NICU,including shorter hospital stay,reduced pain,and improved weight gain,feeding tolerance and neurodevelopment.The main purpose of this study is to determine the efficacy of therapeutic massage on neurodevelopment and growth of preterm infants.

Study details

Child will receive therapeutic massage of 15 mins each session,by the mother, twice a day,once in morning and once in evening(45 mins after or before feeding)which includes 5 mins of tactile stimulation followed by 5 mins of kinaesthetic stimulation again followed by 5 mins of tactile stimulation.

Massage will be done gently,head to toe,from one body part to another, using a smooth, gentle rhythm.

Before the neonate is discharged,mother will be taught about all the steps and technique of tactile and kinaesthetic stimulation (as mentioned in Annexure I) in detail through videos and demonstration,first on mannequin followed by her own neonate.Child will be assessed for growth and neurodevelopment on follow up at corrected gestional age of 40 weeks and corrected gestational age of 3 months.

Voluntary participation

You and your baby's participation in this study is your voluntary decision. Whether to participate or not to participate will not affect your current or future relationship with the KLES Dr. PrabhakarKore Hospital and Medical Research Centre, Belagavi.You are free to discontinue the participation in the study at any time for any reasons. You will not be paid any reimbursement for participation in the research.

Risk and benefits

There is no risk associated with the intervention as such.The intervention will lead to shorter hospital stay,reduced pain,and improved weight gain,feeding tolerance and neurodevelopment.

Privacy and Confidentiality

The only people who will know that you are a research participant are member of the research team. No information about you or provided by you, during research will be disclosed to others without your written consent. When the results of the research are published or discussed in the conferences, no information will be disclosed that would reveal your identity. Any information obtained in connections with this study and that can be identified with you remain confidential and will be disclosed only with your permission.

Financial incentive for participation

You or your baby will not receive any financial assistance for participating in this study.

Queries

If you have any queries you may contact

Dr. **Reg No. BM0120014**

Post Graduate Student

Department of Pediatrics

Jawaharlal Nehru Medical College ,Belagavi-590010

Dr. I
Professor, Department of Pediatrics,
KLE Academy of Higher Education and Research,
Jawaharlal Nehru Medical College,Belagavi-590010

If you have any questions about your rights or research participation you may contact

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You will be given a copy of this form for your information and to keep for your records.

Annexure II

PROFORMA

"Effect of tactile and kinaesthetic stimulation on neuro-development and growth of preterm infants born at < 34 weeks gestational age – Randomised Controlled Trial Study"

Principal Investigator: Dr.Prateek Mohan
Guide:Dr.Manisha Bhandankar

SUBJECT NO.:-_____ IP No :- _____

MATERNAL INFORMATION

1) Name
2) Age
3) Permanent address
4) Telephone No.
5) Educational Status
6) Socio-economic Status
7) Type of Delivery
8) Obstetric Score

NEONATAL INFORMATION:

Date of birth: __/__ /__ Study group : A ☐ B ☐

Gestational Age at Birth (weeks)	
Birth Weight (grams)	
Length at Birth (cm)	
OFC at Birth (cm)	
Date of Admission	
Date of Discharge	
Hospital Stay	
Major problems at discharge	
Feeding – BF/SF at discharge	
Supplements at discharge	
Gestational Age of starting the massage	
Gestational Age of stopping the massage	

	At Birth	At Enrolment (at discharge)	At 6 weeks after discharge or 40 weeks corrected gestational age, whichever is later	At 3 months of corrected gestational age
Length (cm)				
Weight (grams)				
OFC (cm)				
Hammersmith Neonate Neurological Examination				
Hammersmith Infant Neurological Examination				
Prechtl's GMA -Normal -Hypokinesia -Poor Repertoire -Chaotic -Cramped Synchronised -Abnormal fidgety -Absence of fidgety				

Annexure III

Therapeutic Massage consists of 15 mins each session, twice a day,once in morning and once in evening(45 mins after or before feeding)which includes 5 mins of tactile stimulation followed by 5 mins of kinaesthetic stimulation again followed by 5 mins of tactile stimulation

At the beginning put the infant supine on a clean,flat surface.Next,remove any sharp jewellery on fingers and hands.Wash hands properly before touching the interacting with the baby.The room and hands should be warm.Baby should be in awake and alert state at the time of massage.Use 2-3 drops of coconut oil on hands before giving tactile stimulation to the infant.Undress the baby slowly as you move from head to lower limbs.

Maintain physical contact with the baby at all times in order to help him feel secure and comfortable;the infant will show signs of stress if the person giving the massage frequently loses physical contact. Flow gently from one body part to another, using a smooth, gentle rhythm. Use slow,steady, gentle movements; avoid fluttery or ticklish strokes. Every body part should receive 5 strokes each of tactile stimulation.As the infant grows and matures it becomes accustomed to the massage therapy.Stop the massage if baby gets stressed,starts crying and cannot be consoled.

The sequence of Tactile Stimulation is –

Opening Stretch → Over the scalp → Over the forehead → Nasolabial fold → Cheeks → Lips(upper and lower) → Neck → Ear → Chest → Abdomen → Upper and Lower Limbs → Back(occiput to gluteal region) → Buttocks

The sequence of Kinestheic Stimulation is –

(these steps are done at the rate of about 5 per minute)

Begin by holding the baby's wrists and crossing them over the chest, alternating them with one arm on top first, then the other.

↓

Then stretch the arms out alongside the body.

↓

Next, cross the legs and arms over the body:First, bring the left arm across the chest to the bottom of the ribs on the right side; then cross the left leg over the stomach.Repeat on the opposite side.

↓

Then gently stretch out the legs.

↓

End by "bicycling" the legs with flexion and extension softly toward the stomach.

Annexure IV

Hammersmith Neonatal Neurological Examination **Term and preterms at term age**
Ricci D et al Early Hum Devel 2008 **Page 1**

Patient Name **GA** **ID** **Date**
DOB

POSTURE	arms & legs extended or very slightly flexed	legs slightly flexed	leg well-flexed but not adducted	leg well flexed & adducted near to abdomen	abnormal posture: opisthotonus a) arms flexed, b) legs extended
ARM RECOIL	arms do not flex	arms flex slowly not always; not completely	arms flex slowly; more complete	arms flex quickly and completely	arms difficult to extend; snap back forcefully
ARM TRACTION	arms remain straight; no resistance	arms flex slightly or some resistance felt	arms flex well till shoulder lifts, then straighten	arms flex to approx. 100° & maintained as shoulder lifts	flexion of arms <100°; maintained when body lifts up
LEG RECOIL	No flexion	incomplete or variable flexion	complete but slow flexion	complete fast flexion	legs difficult to extend; snap back forcefully
LEG TRACTION	legs straight - no resistance	legs flex slightly or some resistance felt	legs flex well till bottom lifts up	knee flexes & remains flexed when bottom up	flexion stays when back & bottom up
POPLITEAL ANGLE	180°	≈ 150°	≈110°	≈90°	<90°
HEAD CONTROL (1)	no attempt to raise head	infant tries: effort better felt than seen	raises head but drops forward or back	raises head: remains vertical	
HEAD CONTROL (2)	no attempt to raise head	infant tries: effort better felt than seen	raises head but drops forward or back	raises head: remains vertical; it may wobble	head upright or extended; cannot be passively flexed
HEAD LAG	head drops & stays back	tries to lift head but it drops back	able to lift head slightly	lifts head in line with body	head in front of body
VENTRAL SUSPENSION	back curved, head & limbs hang straight	back curved, head ↓, limbs slightly flexed	back slightly curved, limbs flexed	back straight, head in line, limbs flexed	back straight, limbs above body

1	.5	2	.5	3	.5	4	.5	5	
3	0	9	6	60	9	12	0	1	25-27w
1	0	6	2	61	16	12	1	1	28-29w
2	0	4	2	65	17	8	0	2	30-31w
0	0	0	2	81	4	9	0	4	32-34w
0	0	0	0	6	3	90	1	0	Full term

3	1	9	9	44	9	23	2	0	25-27w
1	1	3	4	42	15	33	0	1	28-29w
1	0	8	3	42	10	36	0	0	30-31w
0	0	2	2	54	15	25	0	2	32-34w
0	0	5	2	22	3	67	1	0	Full term

3	0	17	5	51	10	14	0	0	25-27w
7	1	14	7	45	8	18	0	0	28-29w
7	2	15	4	51	7	14	0	0	30-31w
6	2	25	0	59	4	4	0	0	32-34w
0	0	1	0	22	8	69	0	0	Full term

3	0	14	4	18	5	52	0	4	25-27w
0	0	5	2	24	5	62	0	2	28-29w
0	0	10	2	34	2	50	0	2	30-31w
0	0	9	0	38	2	49	0	2	32-34w
0	0	3	1	4	1	91	0	0	Full term

3	1	17	6	35	6	27	1	4	25-27w
1	1	17	2	36	6	35	1	1	28-29w
2	0	21	8	38	5	25	0	1	30-31w
0	4	29	10	43	2	10	0	2	32-34w
0	0	0	1	12	12	72	0	3	Full term

3	0	22	8	46	6	14	0	0	25-27w
5	1	16	5	48	7	17	1	0	28-29w
2	0	15	10	53	5	15	0	0	30-31w
2	0	26	4	49	4	13	0	2	32-34w
0	0	5	5	19	20	51	0	0	Full term

3	0	17	4	46	9	21	0	0	25-27w
0	0	13	5	46	12	24	0	0	28-29w
3	0	14	2	48	13	20	0	0	30-31w
4	0	15	4	55	4	18	0	0	32-34w
0	0	0	6	26	12	56	0	0	Full term

3	0	3	5	57	11	21	0	0	25-27w
1	2	6	4	50	13	24	0	0	28-29w
1	0	2	2	63	11	21	0	0	30-31w
0	0	4	2	77	2	15	0	0	32-34w
0	0	0	4	29	15	52	0	0	Full term

3	3	27	13	36	3	15	0	0	25-27w
3	3	18	7	40	14	15	0	0	28-29w
7	3	16	5	46	7	16	0	0	30-31w
4	0	21	4	56	0	15	0	0	32-34w
0	0	9	4	44	12	31	0	0	Full term

0	0	21	11	38	11	15	4	0	25-27w
3	0	25	8	44	8	10	0	2	28-29w
3	0	22	8	47	5	14	1	0	30-31w
2	0	17	2	56	2	19	0	2	32-34w
0	0	4	5	47	16	28	0	0	Full term

Tone pattern items **Page 2**

FLEXOR TONE (compare arm and leg traction)		arm flexion < leg flexion	arm flexion = leg flexion	arm flexion > leg flexion; difference ≤1 column	arm flexion > leg flexion; difference > 1 colum n
FLEXOR TONE (resting posture)			arms and legs generally flexed	strong arm flexion with strong leg extension *intermittent*	strong arm flexion with strong leg extension *continuous*
LEG TONE (leg traction and popliteal angle)		leg traction > popliteal angle	leg traction = popliteal angle	leg traction < popliteal angle; difference ≤1 column	leg traction < popliteal angle; difference > 1 colum n
HEAD CONTROL (sitting)		neck extension < neck flexion	neck extension = Neck flexion	neck extension > neck flexion; difference ≤ 1 column	neck extension > neck flexion; difference > 1 colum n
NECK AND AXIAL TONE (horizontal)		ventral suspension < head lag	ventral suspension = head lag	ventral suspension > head lag; difference ≤1 column	ventral suspension > head lag; difference > 1 colum n

1	.5	2	.5	3	.5	4	.5	5	
0	0	45	0	27	<1	27	0	1	**25-27w**
0	0	40	<1	40	0	20	<1	0	**28-29w**
0	0	34	<1	47	<1	18	0	1	**30-31w**
0	0	38	<1	36	<1	24	<1	2	**32-34w**
0	0	25	3	53	0	18	0	<1	**Full term**

0	0	0	0	99	<1	0	0	1	**25-27w**
0	0	0	0	96	<1	3	0	1	**28-29w**
0	0	0	0	96	<1	2	0	2	**30-31w**
0	0	0	0	94	<1	2	0	4	**32-34w**
0	0	0	0	99	0	<1	0	<1	**Full term**

0	0	43	<1	34	0	21	<1	1	**25-27w**
0	0	41	0	39	<1	19	0	1	**28-29w**
0	0	38	0	36	<1	22	<1	4	**30-31w**
0	0	19	<1	50	<1	29	<1	2	**32-34w**
0	0	4	0	57	0	35	0	1	**Full term**

0	0	25	0	64	0	9	0	2	**25-27w**
0	0	17	0	70	0	13	0	0	**28-29w**
0	0	18	0	76	0	6	0	0	**30-31w**
0	0	23	0	64	0	13	0	0	**32-34w**
0	0	3	0	94	0	3	0	<1	**Full term**

0	0	20	0	39	0	35	0	6	**25-27w**
0	0	31	0	42	0	26	0	1	**28-29w**
0	0	24	0	49	0	26	0	1	**30-31w**
0	0	17	0	51	0	28	0	4	**32-34w**
0	0	24	0	58	0	18	0	<1	**Full term**

Ricci D, et al Early Human Development 2008:84;751–761

Reflex items **Page 3**

TENDON REFLEX	absent	felt, not seen	seen	'exaggerated'	clonus
SUCK/GAG	no gag / no suck	weak irregular suck only: no stripping	weak regular suck some stripping	strong suck: (a) irregular (b) regular good stripping	no suck but strong clenching
PALMAR GRASP	no response R L	short, weak flexion of fingers R L	strong flexion of fingers R L	strong finger flexion, shoulder ↑ R L	very strong grasp; infant can be lifted off couch R L
PLANTAR GRASP	no response R L	partial plantar flexion of toes R L	toes curve around the examiner's finger R L		
PLACING	no response R L	dorsi-flexion of ankle onl y R L	full placing response with flexion of hip, knee & placing sole on surface R L		
MORO REFLEX	no response or opening of hands only	full abduction at shoulder and extension of the arms; no adduction	full abduction but only delayed or partial adduction	partial abduction at shoulder and extension of arms followed by smooth adduction	• no abduction or adduction; • only forward extension of arms from the shoulders • marked adduction only or

1	.5	2	.5	3	.5	4	.5	5	
0	0	9	0	55	7	13	3	13	**25-27w**
0	0	12	0	50	7	22	4	5	**28-29w**
0	0	24	1	52	1	13	0	9	**30-31w**
0	0	18	0	57	0	17	4	4	**32-34w**
<1	0	21	0	78	0	<1	0	<1	**Full term**

0	0	1	0	3	3	93	0	0	**25-27w**
0	0	3	0	7	0	90	0	0	**28-29w**
0	0	0	0	6	2	92	0	0	**30-31w**
0	0	4	0	10	0	86	0	0	**32-34w**
0	0	1	0	5	0	92	0	2	**Full term**

0	0	5	0	47	7	30	1	10	**25-27w**
0	0	3	1	40	8	43	1	4	**28-29w**
0	0	1	0	51	3	35	0	10	**30-31w**
0	0	7	0	53	3	30	0	7	**32-34w**
<1	0	6	0	84	0	9	0	<1	**Full term**

0	0	4	1	95	0	0	0	0	**25-27w**
0	1	5	2	92	0	0	0	0	**28-29w**
0	0	2	1	97	0	0	0	0	**30-31w**
0	0	2	2	96	0	0	0	0	**32-34w**
<1	0	2	0	98	0	0	0	0	**Full term**

5	2	12	3	78	0	0	0	0	**25-27w**
0	2	12	6	80	0	0	0	0	**28-29w**
1	0	8	8	83	0	0	0	0	**30-31w**
0	0	4	0	96	0	0	0	0	**32-34w**
1	0	18	0	81	0	0	0	0	**Full term**

0	0	13	1	61	4	20	0	1	**25-27w**
0	0	12	1	64	6	15	1	1	**28-29w**
0	0	12	1	51	3	28	0	5	**30-31w**
0	0	23	0	46	2	27	0	2	**32-34w**
0	0	1	0	20	0	79	0	0	**Full term**

Ricci D, et al Early Human Development 2008:84;751–761

Movements **Page 4**

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SPONTANEOUS MOVEMENT (quantity)	no movement	sporadic and short isolated movements	frequent isolated movements	frequent generalized movements	continuous exaggerated movements
SPONTANEOUS MOVEMENT (quality)	only stretches	stretches and random abrupt movements Some smooth movements	fluent movements but mono-tonous	fluent alternating movements of arms + legs; good variability	cramped synchr-onous mouthing jerky or other abnormal movement
HEAD RAISING	no movement	infant rolls head over, chin not raised	infant raises chin, rolls head over	infant brings head and chin up	infant brings head up and keeps it up

1	.5	2	.5	3	.5	4	.5	5	
0	0	15	3	28	3	51	0	0	25-27w
0	0	17	3	26	11	43	0	0	28-29w
0	0	13	0	31	8	48	0	0	30-31w
0	0	20	0	27	0	51	0	2	32-34w
<1	0	3	0	5	0	92	0	<1	Full term

0	0	16	4	42	11	23	1	3	25-27w
0	0	22	5	35	1	23	2	2	28-29w
0	0	20	6	34	2	36	0	2	30-31w
0	0	21	0	15	0	60	0	4	32-34w
2	0	5	0	<1	0	93	0	<1	Full term

0	0	36	6	34	6	14	1	3	25-27w
1	1	35	4	34	9	14	1	1	28-29w
1	1	40	5	28	1	21	1	2	30-31w
0	0	40	0	30	4	22	2	2	32-34w
<1	0	10	0	50	0	40	0	<1	Full term

Abnormal signs

ABN. HAND OR TOE POSTURES		hands open, toes straight most of the time	intermittent fisting or thumb adduction	continuous fisting or thumb adduction; index finger flexion, thumb opposition	continuous big toe extension or flexion of all toes
TREMOR		no trem or or trem or only when crying	tremor only after Moro or occasionally when awake	frequent tremors when awake	continuous tremors
STARTLE	no startle even to sudden noise	no spontan-eous startle but reacts to sudden noise	2-3 spontaneous startles	more than 3 spontaneous startles	continuous startles

1	.5	2	.5	3	.5	4	.5	5	
0	0	57	4	37	0	2	0	0	25-27w
0	0	64	6	28	0	2	0	0	28-29w
0	0	67	1	30	1	1	0	0	30-31w
0	0	75	2	21	0	2	0	0	32-34w
0	0	85	0	12	0	3	0	<1	Full term

0	0	43	1	29	8	16	0	3	25-27w
0	0	43	0	27	9	19	2	0	28-29w
0	0	54	0	24	3	19	0	0	30-31w
0	0	62	0	30	0	4	0	4	32-34w
0	0	88	0	12	0	<1	0	<1	Full term

22	0	40	7	20	1	10	0	0	25-27w
23	1	35	7	30	2	2	0	0	28-29w
37	1	32	1	25	1	3	0	0	30-31w
50	0	35	0	9	0	6	0	0	32-34w
<1	0	94	0	6	0	<1	0	<1	Full term

Ricci D, et al Early Human Development 2008:84;751–761

Behavioural signs, vision, hearing **Page 5**

						1	.5	2	.5	3	.5	4	.5	5	
EYE APPEARANCE	does not open eyes		full conjugated eye mov	transient nystagmus strabismus roving eye movemens sunsetting sign	persistent nystagmus strabismus roving eye movements dow nward deviation	6	0	0	0	74	4	16	0	0	25-27w
						2	0	0	0	80	2	15	1	0	28-29w
						5	0	0	0	80	2	13	0	0	30-31w
						4	0	0	0	87	2	7	0	0	32-34w
						7	0	0	0	92	0	1	0	<1	Full term
AUDITORY ORIENTATION	no reaction	auditory startle; Brightens and stills; no true orientati - on	shifting of eyes, head might turn towards source	prolonged head turn to stimulus; search with eyes; smooth	turns head and eyes towards noise every time; jerky abrupt	5	1	28	0	57	1	8	0	0	25-27w
						2	0	23	10	50	6	9	0	0	28-29w
						5	1	27	7	51	1	8	0	0	30-31w
						3	0	14	0	73	3	7	0	0	32-34w
						<1	0	30	0	50	0	20	0	<1	Full term
VISUAL ORIENTATION	does not follow or focus on stimuli	stills, focuses follows briefly to the side but loses stimuli	follows horizontal -ly and vertically; no head turn	follows horizon -tally and vertically; turns head	follows in a circle	6	0	7	2	25	3	26	9	22	25-27w
						0	0	7	1	33	7	21	15	16	28-29w
						1	0	9	0	27	5	25	10	23	30-31w
						0	0	10	0	42	10	38	0	0	32-34w
						<1	0	7	0	41	0	51	0	1	Full term
ALERTNESS	will not respond to stimuli	when awake, looks only briefly	when awake, looks at stimuli but loses them	keeps interest in stimuli	does not tire (hyper-reactive)	6	0	22	1	48	3	20	0	0	25-27w
						1	0	17	4	60	3	14	1	0	28-29w
						0	0	21	1	43	2	33	0	0	30-31w
						0	0	7	3	54	0	36	0	0	32-34w
						1	0	2	0	48	0	49	0	<1	Full term
IRRITABILITY	quiet all the time, not irritabie to any stimuli	awakes, cries some -times when handled	cries often when handled	cries always when handled	cries even when not handled	12	1	52	0	31	0	3	0	1	25-27w
						16	2	47	2	27	1	5	0	0	28-29w
						27	0	47	1	22	0	2	0	1	30-31w
						23	0	49	0	23	0	5	0	0	32-34w
						<1	0	93	0	5	0	2	0	<1	Full term
CONSOLABILITY	not crying consoling not needed	cries briefly; consol -ing not needed	cries; becomes quiet when talked to	cries; needs picking up to console	cries cannot be consoled	10	0	29	0	29	3	29	0	0	25-27w
						17	1	19	2	29	7	22	1	2	28-29w
						27	0	18	0	28	2	22	1	2	30-31w
						23	0	9	0	32	2	28	0	6	32-34w
						1	0	41	0	45	0	12	0	<1	Full term
CRY	no cry at all	whimpe -ring cry only	cries to stimuli but normal pitch		high pitched cry; often continuous	11	0	11	0	78	0	0	0	0	25-27w
						16	0	5	2	77	0	0	0	0	28-29w
						26	1	3	1	69	0	0	0	0	30-31w
						23	0	6	2	69	0	0	0	0	32-34w
						<1	0	7	0	92	0	0	0	1	Full z

Reference

Ricci D, Romeo DMM, Haataja L et al Neurological examination of preterm infants at term equivalent age. Early Human Development 2008:84;751–761

Annexure V

HAMMERSMITH INFANT NEUROLOGICAL EXAMINATION (v 08.02.19)

Name **Date of birth**

Gestational age **Date of examination**

Chronological age / Corrected age **Head circumference**

SUMMARY OF EXAMINATION
Global score (max 78)
Number of asymmetries
Behavioural score (not part of the optimality score)

Cranial nerve function	**score**	**(max 15)**
Posture	**score**	**(max 18)**
Movements	**score**	**(max 6)**
Tone	**score**	**(max 24)**
Reflexes and reactions	**score**	**(max 15)**

COMMENTS

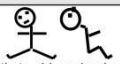
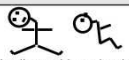
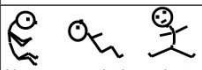
(Throughout the exam, if a response is not optimal but not poor enough to score 1, give a score of 2)

NEUROLOGICAL EXAMINATION

ASSESSMENT OF CRANIAL NERVE FUNCTION

	score 3	2	score 1	score 0	score	Asymmetry / Comments
Facial appearance (at rest and when crying or stimulated)	Smiles or reacts to stimuli by closing eyes and grimacing		Closes eyes but not tightly, poor facial expression	Expressionless, does not react to stimuli		
Eye movements	Normal conjugate eye movements		**Intermittent** Deviation of eyes or abnormal movements	**Continuous** Deviation of eyes or abnormal movements		
Visual response Test ability to follow a black/white target	Follows the target in a complete arc		Follows target in an incomplete or asymmetrical arc	Does not follow the target		
Auditory response Test the response to a rattle	Reacts to stimuli from both sides		Doubtful reaction to stimuli or asymmetry of response	No response		
Sucking/swallowing Watch infant suck on breast or bottle. If older, ask about feeding, assoc. cough, excessive dribbling	Good suck and swallowing		Poor suck and/or swallow	No sucking reflex, no swallowing		

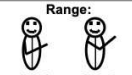
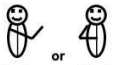
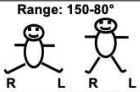
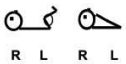
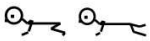
ASSESSMENT OF POSTURE (note any asymmetries)

	score 3	score 2	score 1	score 0	sc	Asymmetry / comments
Head in sitting	 Straight; in midline		 Slightly to side *or* backward *or* forward	 Markedly to side *or* backward *or* forward		
Trunk in sitting	 Straight		 Slightly curved or bent to side	 Very rounded rocketing back bent sideway		
Arms at rest	In a neutral position, central straight or slightly bent		**Slight** internal rotation *or* external rotation **Intermittent** dystonic posture	**Marked** internal rotation *or* external rotation or dystonic posture hemiplegic posture		
Hands	Hands open		**Intermittent** adducted thumb *or* fisting	**Persistent** adducted thumb *or* fisting		
Legs in sitting in supine and in standing	Able to sit with a straight back and legs straight or slightly bent (long sitting)  Legs in neutral position straight *or* slightly bent	**Slight** internal rotation or external rotation	Sit with straight back but knees bent at 15-20 °  Internal rotation *or* external rotation at the hips	Unable to sit straight unless knees markedly bent (no long sitting)  **Marked** internal rotation *or* external rotation *or* fixed extension or flexion or contractures at hips and knees		
Feet in supine and in standing	Central in neutral position Toes straight midway between flexion and extension		**Slight** internal rotation *or* external rotation **Intermittent** Tendency to stand on tiptoes or toes up or curling under	**Marked** internal rotation *or* external rotation at the ankle **Persistent** Tendency to stand on tiptoes *or* toes up or curling under		

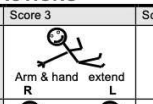
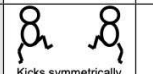
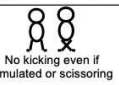
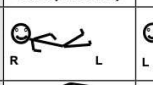
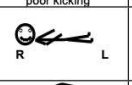
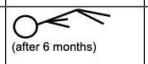
ASSESSMENT OF MOVEMENTS

	Score 3	Score 2	Score 1	Score 0	score	Asymmetry / comments
Quantity Watch infant lying in supine	Normal		Excessive or sluggish	Minimal or none		
Quality Observe infant's spontaneous voluntary motor activity during the course of the assessment	Free, alternating, and smooth		Jerky Slight tremor	• Cramped & synchronous • Extensor spasms • Athetoid • Ataxic • Very tremulous • Myoclonic spasm • Dystonic movement		

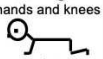
ASSESSMENT OF TONE

	Score 3	Score 2	Score 1	Score 0	sc	Asym/Co
Scarf sign Take the infant's hand and pull the arm across the chest until there is resistance. Note the position of the elbow in relation to the midline.	**Range:** 					
Passive shoulder elevation Lift arm up alongside infant's head. Note resistance at shoulder and elbow.	Resistance overcomeable 	Resistance difficult to overcome R L	No resistance 	Resistance, not overcomeable 		
Pronation/supination Steady the upper arm while pronating and supinating forearm, note resistance	Full pronation and supination, no resistance		Resistance to full pronation / supination overcomeable	Full pronation and supination not possible, marked resistance		
Hip adductors With both the infant's legs extended, abduct them as far as possible. The angle formed by the legs is noted.	**Range: 150-80°** 	**150-160°** 	**>170°** 	**<80°** 		
Popliteal angle Keeping the infant's bottom on the bed, flex both hips onto the abdomen, then extend the knees until there is resistance. Note the angle between upper and lower leg.	**Range: 150°-100°** 	**150-160°** 	**~90° or > 170°** 	**<80°** 		
Ankle dorsiflexion With knee extended, dorsiflex the ankle. Note the angle between foot and leg.	**Range: 30°-85°** 	**20-30°** 	**<20°or 90°**	**> 90°** 		
Pull to sit Pull infant to sit by the wrists. (support head if necessary)						
Ventral suspension Hold infant horizontally around trunk in ventral suspension; note position of back, limbs and head.						

REFLEXES AND REACTIONS

	Score 3	Score 2	Score 1	Score 0	sc	Asym / Co
Arm protection Pull the infant by one arm from the supine position (steady the contralateral hip) and note the reaction of arm on opposite side.	 Arm & hand extend R L		 Arm semi-flexed R L	 Arm fully flexed R L		
Vertical suspension hold infant under axilla making sure legs do not touch any surface – you may "tickle" feet to stimulate kicking.	 Kicks symmetrically		 Kicks one leg more or poor kicking	 No kicking even if stimulated or scissoring		
Lateral tilting (describe side up). Hold infant up vertically near to hips and tilt sideways towards the horizontal. Note response of trunk, spine, limbs and head.						
Forward parachute Hold infant up vertically and quickly tilt forwards. Note reaction /symmetry of arm responses,	 (after 6 months)		 (after 6 months)			
Tendon Reflexes Have child relaxed, sitting or lying – use small hammer	Easily elicitable biceps knee ankle	Mildly brisk bicep knee ankle	Brisk biceps knee ankle	Clonus or absent biceps knee ankle		

SECTION 2 MOTOR MILESTONES (not scored; note asymmetries)

Head control	Unable to maintain head upright normal to 3m	Wobbles normal up to 4m	Maintained upright all the time normal from 5m			**Please note age at which maximum skill is achieved**
Sitting	Cannot sit	With support at hips  normal at 4m	Props  normal at 6m	Stable sit  normal at 7-8m	Pivots (rotates)  normal at 9m	Observed: Reported (age):
Voluntary grasp – note side	No grasp	Uses whole hand	Index finger and thumb but immature grasp	Pincer grasp		Observed: Reported (age):
Ability to kick in supine	No kicking	Kicks horizontally but legs do not lift	Upward (vertically)  normal at 3m	Touches leg  normal at 4-5m	Touches toes  normal at 5-6m	Observed: Reported (age):
Rolling - note through which side(s)	No rolling	Rolling to side normal at 4m	Prone to supine normal at 6 m	Supine to prone normal at 6 m		Observed: Reported (age):
Crawling - note if bottom shuffling	Does not lift head	On elbows  normal at 3m	On outstretched hands  normal at 4m	Crawling flat on abdomen  normal at 8m	Crawling on hands and knees  normal at 10m	Observed: Reported (age):
Standing	Does not support weight	Supports weight normal at 4m	Stands with support normal at 7m	Stands unaided normal at 12m		Observed: Reported (age):
Walking		Bouncing normal at 6m	Cruising (walks holding on) normal at 12m	Walking independently normal by 15m		Observed: Reported (age):

SECTION 3 BEHAVIOUR (not scored)

	1	2	3	4	5	6	Comment
Conscious state	Unrousable	Drowsy	Sleep but wakes easily	Awake but no interest	Loses interest	Maintains interest	
Emotional state	Irritable, not consolable	Irritable, carer can console	Irritable when approached	Neither happy or unhappy	Happy and smiling		
Social orientation	Avoiding, withdrawn	Hesitant	Accepts approach	Friendly			

This is the official form for use with the Hammersmith Infant Neurological Examination.
Its content and scoring system are not to be changed. ***Main reference*** *Haataja L et al J Peds 1999;135:153-61*
For enquiries about the examination, *please contact Prof Frances Cowan f.cowan@imperial.ac.uk,*
Prof Leena Haataja leena.haataja@hus.fi or Prof Eugenio Mercuri eugeniomercuri@unicatt.it
https://www.mackeith.co.uk/hammersmith-neurological-examinations/

CONTROL GROUP

S No.	IP Number	Mother's Age(years)	Mother's Educational Status		Socio Economic Status (Modified Kuppuswamy Classification)	Type of delivery	Obstetric Score	Gender	Gestational Age at birth(weeks)		AT Birth		Hospital Stay (days)	Major Problems at discharge	Mechanical ventilation/CPAP	Gestational age of starting the massage (weeks)	Gestational age of stopping the massage (weeks)		At Enrolment (at discharge)			At 6 weeks after discharge or corrected gestational age of 40 weeks			At corrected gestational age of 3 months		HNNE score
1	1036402	20	10th standard	10th standard	Lower Middle (III)	LSCS	Primigravida	Female	32 + 4d	42	1400	28	21	CONS sepsis	Yes			44	1480	29	48	2240	33	54	3320	37.5	31
2	1080488	31		Graduate	Upper Middle (II)	LSCS	G2A1	Male	34	42	1780	30	16	-	-			43	1770	31	45	2220	33.5	57	4320	37.5	31
3	1080489	31		Graduate	Upper Middle (II)	LSCS	G2A1	Male	34	41	1410	29	16	-	-			41	1310	29	42	1760	32	55	4120	37.5	27
4	1047212	25	Home maker	Graduate	Upper Middle (II)	LSCS	Primigravida	Male	32 + 2d	43	1460	29	15	-	Yes			45	1310	30	50	2580	33	56	4800	38	28
5	1055275	26	Home maker	Graduate	Upper Middle (II)	LSCS	Primigravida	Female	32 + 4d	44	2000	32	9		Yes			44	1880	33	46	2400	33	59	5420	39	29
6	1044008	38	Home maker	Post Graduate	Upper (I)	LSCS	G4P2L2A1	Male	30 + 2 d	35	914	27	32	-	Yes			37	1260	29	40	1800	32	48	3060	39	26
7	1096712	32	Home maker	12th standard	Lower Middle (III)	LSCS	G4P3L1D2	Male	32	42	1540	30	26	Enterobacter sepsis	-			43	1450	30	46	2280	34	54	4600	38	32
8	1065422	19	Home maker	10th standard	Lower Middle (III)	LSCS	Primigravida	Male	34	41	1480	29	23	-	-			42	1610	29	43	2340	33	50	4000	37	30
9	1065423	19	Home maker	10th standard	Lower Middle (III)	LSCS	Primigravida	Male	34	40	1240	28	23	-	-			41	1390	28.5	41	2040	31	50.5	3540	36.5	23
10	1078687	31		Graduate	Upper Middle (II)	LSCS	G5P2L2A2	Female	33	37	980	27	12	-	Yes			37	1120	27	43	2060	33	52	4120	38	26
11	1078690	31		Graduate	Upper Middle (II)	LSCS	G5P2L2A2	Male	33	49	1680	29	12	-	-			49	1800	29	50	3240	35	55	4950	38.5	31
12	1075552	22	Home maker	12th standard	Upper Middle (II)	LSCS	G2P1L1	Male	31	42	1460	28	17	Enterobacter sepsis	Yes			43	1400	29	46	2800	35	52	4780	38	28
13	1054177	27	Home maker	10th standard	Lower Middle (III)	LSCS	G3P1L1A1	Male	31 + 6 d	38	1300	27	20	Candida sepsis,Meningitis	Yes			40	1590	28.5	44	2410	32	54	4420	37.5	29
14	1084192	26	Home maker	Graduate	Upper Middle (II)	NVD	Primigravida	Male	28	35	975	23	52	-	Yes			39	1120	28	40	1500	31	57	3200	37	28
15	1082814	24	Home maker	Graduate	Lower Middle (III)	LSCS	G2P1L1	Male	33	42	1560	29	13	-	-			43	1510	29	48	2340	36	58	5320	40	27
16	1107216	20	Home maker	8th standard	Lower (V)	LSCS	G2P1L1	Male	31 + 4 d	39	1400	29	14	-	-			40	1320	30	46	2360	34	55	4100	37	25
17	1107738	18	Home maker	6th standard	Lower (V)	LSCS	Primigravida	Male	34	40	1860	30	11		Yes			40	1540	30	45	2400	33	53	4850	38	26
18	1088862	23	Home maker	12th standard	Upper Middle (II)	LSCS	Primigravida	Male	32	40	1330	29	18	-	-			41	1460	30	45	2300	34	56	5340	41	34
19	1063851	21	Home maker	10th standard	Upper Lower (IV)	LSCS	Primigravida	Male	32 + 3 d	39	1300	26	35	Enterobacter sepsis	Yes			41	1380	28	42	1900	29	49	4900	32.5	27
20	1063852	21	Home maker	10th standard	Upper Lower (IV)	LSCS	Primigravida	Male	32 + 3 d	40	1360	26	35	Staphylococcus epidermidis sepsis,Enterobacter cloacae sepsis,DIC	Yes			41.5	1480	28	42	2100	30	54	5150	36	27
21	1061657	21	Home maker	12th standard	Lower Middle (III)	LSCS	Primigravida	Male	34	46	1630	32	10	Enterobacter sepsis,Klebsiella sepsis	Yes			47	2140	34	48	2780	36	56	5100	37	25
22	1084814	24	Home maker	12th standard	Lower Middle (III)	LSCS	Primigravida	Female	27 + 5 d	38	1500	29	56	Klebsiella sepsis	Yes			42	1840	31	45	2160	33	55	4800	39.5	27
23	1084815	24	Home maker	12th standard	Lower Middle (III)	LSCS	Primigravida	Female	27 + 5 d	35	990	27	56	RDS	Yes			39	1130	30	42	1560	30	48	4100	38	27
24	1004208	26	Engineer	Graduate	Upper Middle (II)	LSCS	Primigravida	Male	32	38	1340	28	21	PDA	-			39	1420	29	46	1920	33.3	56	4380	39	27
25	1108667	24	Home maker	Graduate	Upper Middle (II)	NVD	G2P1L1	Female	31 + 4 d	37	1500	27	11	-	-			38	1380	28	41	1900	30.5	52	4800	38	27
26	1108669	24	Home maker	Graduate	Upper Middle (II)	NVD	G2P1L1	Male	31 + 4 d	40	1700	29	11	-	-			40.5	1560	30	44	2220	33	55	4920	37	32
27	1068749	38	Teacher	Graduate	Lower Middle (III)	LSCS	Primigravida	Male	30	36	1050	27	30	-	-			37	1030	28.5	40	1710	31	49	5020	38	30
28	1087711	23	Engineer	Graduate	Upper (I)	LSCS	Primigravida	Male	32	42	2000	31.5	18		-			43.5	1800	32	48	2700	34	55	5850	39.2	24
29	1087712	23	Engineer	Graduate	Upper (I)	LSCS	Primigravida	Male	32	41	1820	30	18		-			43	1650	31	48	2600	34.5	53	5840	38	28
30	1095670	29	Home maker	9th standard	Lower (V)	LSCS	Primigravida	Male	32 + 1d	39	1260	29	12	PDA	-			40	1220	29.5	44	2200	33.5	54	4480	38	28

	HINE score
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Table 1

S No.	IP No.				HNNE					HINE	
		Posture (max score 10)	Tone Pattern items (max score 5)	Reflex Items (max score 6)	Movements (max score 3)	Abnormal Signs (max score 3)	Behavioural signs, vision, hearing (max score 7)	Cranial Nerve function (max score 15)	Posture (max score 18)	Movement (max score 6)	Tone (max score 24)
1	1036402	9	5	5	3	3	6	14	12	6	20
2	1080488	9	5	6	3	3	5	13	16	5	22
3	1080489	8	5	4	3	3	4	14	15	6	20
4	1047212	8	5	3	3	3	6	14	10	5	24
5	1055275	9	5	4	3	3	5	15	12	6	24
6	1044008	7	4	3	3	3	6	14	7	3	17
7	1096712	9	5	6	3	2	7	15	15	6	22
8	1065422	10	5	5	3	3	4	14	13	5	21
9	1065423	7	4	2	3	3	4	13	9	4	21
10	1078687	9	5	2	3	3	4	13	15	5	22
11	1078690	9	5	5	3	3	6	15	16	6	22
12	1075552	9	5	3	3	3	5	14	14	6	22
13	1054177	8	4	6	3	1	7	10	9	4	16
14	1084192	8	4	5	3	1	7	13	14	6	21
15	1082814	8	4	3	3	2	7	14	16	6	24
16	1107216	7	3	6	2	3	4	13	12	5	21
17	1107738	7	4	5	3	2	5	13	14	5	21
18	1088862	10	5	6	3	3	7	14	11	5	17
19	1063851	9	5	4	3	3	3	14	11	5	19
20	1063852	7	4	5	3	3	5	15	12	6	19
21	1061657	7	5	4	3	3	3	13	14	4	20
22	1084814	8	5	2	3	3	6	11	12	5	18
23	1084815	8	5	3	3	3	5	8	10	4	18
24	1004208	7	4	6	3	3	4	11	11	4	21
25	1108667	8	4	3	3	3	6	14	14	5	20
26	1108669	9	5	5	3	3	7	15	15	6	21
27	1068749	9	4	5	3	3	6	9	11	4	19
28	1087711	7	4	3	3	3	4	10	11	5	20
29	1087712	8	5	3	3	3	6	13	12	5	21
30	1095698	8	5	4	3	3	5	12	13	5	19

Reflexes and reactions (max score 15)
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Table 1

S No.	IP No.				HNNE					HINE		
		Posture (max score 10)	Tone Pattern items (max score 5)	Reflex Items (max score 6)	Movements (max score 3)	Abnormal Signs (max score 3)	Behavioural signs, vision, hearing (max score 7)	Cranial Nerve function (max score 15)	Posture (max score 18)	Movement (max score 6)	Tone (max score 24)	Reflexes and reactions (max score 15)
1	1060145	7	5	5	3	3	7	15	15	6	24	12
2	1025111	9	5	5	3	1	7	14	12	5	20	9
3	1059497	10	5	6	3	3	5	14	9	4	24	8
4	1058409	9	5	5	3	3	7	14	5	4	15	3
5	1049862	10	5	2	3	3	6	15	14	6	24	9
6	1049863	8	4	3	3	3	6	15	18	6	24	9
7	1076060	8	4	5	3	3	7	14	16	6	24	12
8	1076064	10	5	5	3	3	6	15	17	6	22	8
9	1061140	7	3	5	3	3	4	15	15	6	21	12
10	1049603	7	4	4	3	3	7	15	17	6	22	12
11	1051760	10	5	6	3	3	7	15	13	6	22	11
12	1055431	8	5	5	3	2	6	15	15	6	24	12
13	1053811	9	5	6	3	1	7	15	16	6	24	12
14	1053937	10	4	3	3	3	3	15	11	6	22	11
15	1071755	10	4	6	3	3	7	14	16	5	22	9
16	1071756	10	4	6	3	3	7	15	16	6	23	11
17	1072940	10	5	6	3	3	7	15	16	5	24	12
18	1020228	5	4	3	3	3	7	14	15	4	21	9
19	1067132	9	5	4	3	3	6	15	16	6	24	12
20	1088510	10	5	6	3	3	7	15	17	6	24	10
21	1068895	10	5	5	3	3	5	14	17	5	23	11
22	1068896	9	5	4	3	3	5	15	16	4	18	6
23	1069018	9	5	6	3	3	7	12	10	4	22	9
24	1032734	10	5	2	3	3	5	12	17	5	24	12
25	1090098	9	5	5	3	3	7	14	16	4	24	9
26	1095698	7	5	4	3	3	5	14	15	6	23	11
27	1084993	9	5	5	3	3	7	13	16	5	21	9
28	1070269	9	5	5	3	3	7	15	17	6	24	10
29	1078348	7	4	3	3	3	4	15	16	5	23	11
30	1078350	10	5	5	3	3	6	15	13	5	23	9

S No.	IP Number	Mother's Age(years)	Mother's Educational Status		Socio Economic Status (Modified Kuppuswamy Classification)	Type of delivery	Obstetric Score
1	1060145	26	MA (Bank Manager)	Post Graduate	Upper (I)	LSCS	Primigravida
2	1025111	25	BA (Homemaker)	Graduate	Lower Middle (III)	LSCS	Primigravida
3	1059497	31	Home maker	12th standard	Lower Middle (III)	LSCS	Primigravida
4	1058409	32	Home maker	12th standard	Upper Middle (II)	LSCS	Primigravida
5	1049862	33	MDS (Orthodontist)	Post Graduate	Upper (I)	LSCS	G2A1
6	1049863	33	MDS (Orthodontist)	Post Graduate	Upper (I)	LSCS	G2A1
7	1076060	33	MBA	Post Graduate	Upper Middle (II)	LSCS	Primigravida
8	1076064	33	MBA	Post Graduate	Upper Middle (II)	LSCS	Primigravida
9	1061140	29	MBA	Post Graduate	Upper (I)	LSCS	Primigravida
10	1049603	36	BA (Homemaker)	Graduate	Upper Middle (II)	LSCS	G3P1L1A1
11	1051760	25	B.Com	Graduate	Lower Middle (III)	LSCS	Primigravida
12	1055431	30	Home maker	10th standard	Upper Lower (IV)	LSCS	Primigravida
13	1053811	30	Teacher	Graduate	Upper Middle (II)	LSCS	G3A2
14	1053937	30	BA (Homemaker)	Graduate	Upper (I)	NVD	G3A2
15	1071755	28	Home maker	Graduate	Lower Middle (III)	LSCS	G2A1
16	1071756	28	Home maker	Graduate	Lower Middle (III)	LSCS	G2A1
17	1072940	31	Banker	Graduate	Upper Middle (II)	LSCS	Primigravida
18	1020228	26	Teacher	Graduate	Upper Middle (II)	LSCS	Primigravida
19	1067132	26	Doctor	Post Graduate	Upper Middle (II)	LSCS	Primigravida

20	1088510	29	Home maker	Graduate	Lower Middle (III)	LSCS	G3A2
21	1068895	30	10th standard	10th standard	Upper Lower (IV)	LSCS	G3P2L2
22	1068896	30	10th standard	10th standard	Upper Lower (IV)	LSCS	G3P2L2
23	1069018	28	MA	Post Graduate	Upper (I)	NVD	G3P1L1A1
24	1032734	27	MTech	Post Graduate	Upper (I)	NVD	G3P1L1A1
25	1090098	30	MA	Post Graduate	Upper (I)	NVD	G2A1
26	1095698	29	12th standard	12th standard	Lower Middle (III)	LSCS	Primigravida
27	1084993	27	BSc	Graduate	Upper Middle (II)	LSCS	Primigravida
28	1070269	23	10th standard	10th standard	Upper Lower (IV)	LSCS	G2P1L1
29	1078348	34		Graduate	Upper Middle (II)	LSCS	Primigravida
30	1078350	34		Graduate	Upper Middle (II)	LSCS	Primigravida

Gender	Gestational Age at birth(weeks)	At Birth		OFC(cm)	Hospital Stay (days)	Major Problems at discharge	Mechanical ventilation/CPAP
		Length(cm)	Weight(gram				
Female	32	38	1240	28	22	-	-
Male	34	43	1600	29.5	12	-	-
Male	32	45	1830	29	9	-	Yes
Female	26 + 3d	30	680	23	48	-	Yes
Male	31 + 2d	38	1720	32	19	Klebsiella Sepsis,Apnea of prematurity	Yes
Male	31 + 2d	45	1710	31	19	PDA	Yes
Male	31	45	1500	29	15	-	-
Male	31	45	1600	29	15	-	Yes
Female	33 + 6d	40	1640	31	9	-	-
Male	34	43	1380	30	10	-	-
Male	32 + 1d	37	1200	28	26	-	Yes
Male	32 + 5d	39	2200	28	28	-	-
Male	32	38	1200	28	14	RDS	Yes
Female	27 + 6d	34	671	24	54	-	Yes
Male	28 + 1d	37	1100	28	42		Yes
Female	28 + 1d	38.6	1120	25	42		Yes
Male	32 + 3d	42	1550	32	15	-	-
Male	29 + 5d	39	1050	27	42	PDA with small ASD	Yes
Male	28	32.5	813	25	51	-	Yes

Male	33 + 6d	39	1200	29	11	-	-
Female	34	40	1700	29	17	-	-
Male	34	39	1240	27	17	-	-
Male	31 + 6 d	37	1380	29	10	-	Yes
Female	27 + 4d	34	900	25	48	ROP	Yes
Male	34	44	2300	30	5	-	-
Male	32 + 1d	37	1260	30	12	PDA	Yes
Male	34	40	1300	26	26	-	-
Male	34	46	1900	30	10	-	-
Female	33 + 5d	40	1190	29	9	-	-
Male	33 + 5d	45	2000	32	9	small mid muscular VSD	Yes

Gestational age of starting the massage (weeks)	Gestational age of stopping the massage (weeks)	At Enrolment (at discharge) Length(cm)	Weight (grams)	OFC(cm)	At 6 weeks after discharge or corrected gestational age of 40 weeks Length(cm)		OFC(cm)
35 + 1 d	41	39	1350	29	44	2020	30
35 + 5 d	40 + 3 d	44	1630	30	48	2560	33
33 + 2 d	40	45	1680	29	46	2040	31.5
33 + 3d	42	34	1190	26	44	2100	31.5
34	41	38	1710	32	47	2600	35
34	41	45	1590	31	47	2460	34
33 + 5d	42	45	1350	29	46	2460	34
33 + 5d	42	46	1460	29	49	2900	36.5
35 + 1d	40 + 2d	40	1640	31	47	2580	33
35 + 3d	40 + 3 d	44	1300	30	48	2180	34.5
35 + 6d	40	39	1335	29.5	41	1960	33
34 + 3d	41	39	1780	30	48	2520	34
34	40	40	1240	31	42	2060	33
35 +4d	42	39	1230	30	42	1920	32.5
35 + 1 d	40	39	1300	32	44	2220	34
35 + 1 d	40	40	1260	28	44	2320	33
34 + 2 d	41	43	1600	32	46	2900	35
35	42	41	1120	28	44	1600	32
35 + 5 d	41	37	1240	31	39	1700	31.5

35 + 3d	42	40	1230	30	42	1860	31
36 + 3d	42	41	1830	29	46	2560	32
36 + 3d	42	40	1380	28.5	48	2120	32
33 + 2 d	40	37	1300	29	45	2440	33
34 + 3d	41	39	1230	28	47	2540	32
34 + 5 d	42	44	2270	31	53	3860	35.5
34	40	38	1220	30	44	2200	33.5
37 + 5 d	44	42	1500	29	44	1720	31
35 + 3d	42	46	1780	31	46	2600	32
35	41	40	1100	29	43	1820	32.5
35	41	46	1880	32	49	2580	33.5

Length(cm)	At corrected gestational age of 3 months Weight(gram	OFC(cm)	HNNE score	HINE score
53	4400	41	30	72
57	5200	38	31	60
53	5860	39	32	59
56	4100	37	32	41
56	5160	39	29	68
57	4520	39	27	72
60	5660	41	30	72
61	6100	42	32	68
58	5280	38	25	69
56	4920	37	28	72
56	4460	38	33	67
59	5880	41	28	72
57.5	5800	38.5	31	73
51	3600	38.2	26	65
51	4150	38.5	33	66
51	4400	39	33	71
54	5100	41	34	72
56	4540	38.5	25	63
51	3760	37	30	73

53.5	3800	36	34	72
56	4860	39	31	70
57	4800	38	29	59
54	4140	38	33	57
59	4780	38.5	28	70
58	5650	39	32	67
54	4480	38	27	69
50	4020	38	32	64
54	5520	38	32	72
55	4000	38	24	70
56	5320	39	32	65