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Original Article

Paediatrics Section

Multimodal Sensory Stimulation among Very Low Birth Weight Preterm Newborns: A Quasi-experimental Study at a Tertiary Care Hospital in Agartala, Tripura, India

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ABSTRACT

Introduction: There is a continuous search for an effective intervention to help preterm low birth weight neonates overcome their poor growth and developmental outcomes. Most researchers have examined the effect of Oromotor Stimulation (OMS) on feeding performance. Studies exploring Multimodal Sensory Stimulation (MSS) on various outcome parameters are sparse and reveal inconsistent results.

Aim: To analyse the effectiveness of MSS in improving weight gain, length of hospitalisation, and feeding performance in preterm Very Low Birth Weight (VLBW) neonates.

Materials and Methods: This quasi-experimental study was conducted between June 2021 and December 2022 in the Paediatrics Department of Agartala Government Medical College, Agartala, Tripura, India. A total of 104 hospitalised neonates with gestational age from 28 to less than 37 weeks and birth weight from 1000 to less than 1500 grams (VLBW) were included in the study. All neonates received standard care and Kangaroo Mother Care (KMC). On the advice of some faculties, several of them also received MSS. All neonates were divided into two groups: those who received MSS and those who did not, and they were monitored until discharge. Mean hospitalisation length, weight gain, and transition time were derived and statistically analysed using Chi-square and Mann-Whitney U tests.

Results: In the present study, the mean gestational age was 32.04±1.75 and 32.679±1.19 weeks, and the M:F ratio was 1.43:1 and 1.30:1 in the MSS-given and MSS-not given groups, respectively. Mean weight gain was significantly higher in the MSS-given group (97.00±123.09 g versus- 23.42±43.96 g). Mean hospitalisation length was longer in the MSS-given group, but transition time did not differ significantly across the groups.

Conclusion: Multimodal sensory stimulation is effective in promoting weight gain in preterm VLBW neonates.

Keywords: Growth and development, Kangaroo mother care, Massage, Weight gain

INTRODUCTION

As a healthy foetus develops, the brain is incredibly malleable. An ideal environment for the development and maturation of synapses in the brain is provided by the intrauterine environment. The Central Nervous System (CNS) begins to myelinate by 14 weeks of gestation and reaches its peak between 25 and 37 weeks [1]. Favourable sensory inputs provided by the intrauterine environment, along with restricted access to harmful sensory inputs, are essential for optimal brain development. Preterm neonates (born before 37 full weeks of gestation) [2] are not fully prepared for handling the wide range of sensory experiences of the extrauterine world, while term neonates are [3] Hence, preterm newborns are more likely to develop long-term growth and developmental morbidities [4].

Additionally, in preterm newborns, optimal breastfeeding is restricted because of gut immaturity, inefficient sucking, poor coordination of swallowing and breathing, and weak oromotor abilities [5]. Recent research suggests that Oromotor Stimulation (OMS) of preterm babies can enhance sucking ability and shorten the transition time from gavage to oral feeding [6-8]. Multimodal Sensory Stimulation (MSS) is a collection of interventions that provide simple, structured, and repetitive sensory stimuli through two or more sensory modes, expecting to elicit a physiological and/or behavioural response in a patient. The various sensory modes include visual, auditory, tactile, olfactory, gustatory, vestibular, kinaesthetic, and proprioceptive senses [9].

Thabet AM and Sayed ZA in a Randomised Controlled Trial (RCT), observed that OMS was effective in improving the feeding performance of preterm neonates, reducing the duration of hospital stay, and increasing their weight [10]. Another RCT by Govindarajan K et al., from India, demonstrated that combined sensory-motor oral stimulation had shortened the duration of hospitalisation in preterm neonates, while there was no significant effect on feeding performance and weight gain [11]. Alice JJ et al., investigated the effect of tactile and kinaesthetic stimulation in preterm neonates and observed its positive effect on weight gain without any effect on feeding performance or hospital stay [12]. Whereas, the RCT of Zhang Y et al., found that non-nutritive sucking and OMS in preterm neonates had a beneficial effect on the reduction in transition time, but no such effect was found on weight gain and hospitalisation length [13]. Mahdieh S et al., observed enhanced weight gain in preterm infants following Multimodal Sensory Stimulation (MSS) [14]. The effect of OMS was also evaluated by Arora K et al., and found it to be beneficial in improving oromotor skills, growth velocity, and decreasing transition time from gavage to full independent oral feeds in preterm infants [15]. Massage therapy and Kangaroo Mother Care (KMC) were found to be equally effective in improving weight and reducing the length of hospitalisation in the study of Rangey PS and Sheth M [16]. Then again, the study of Bragelien R et al., revealed that OMS did not cause a reduction in transition time and length of hospitalisation in premature infants [17].

Thus, different studies in the medical literature examined the effect of a wide variety of stimulations on different outcome parameters [7,10-14]. Most of the studies [5,6,8,10,13,15,17] examined the effect of OMS as a primary intervention. Studies examining MSS on feeding performance, length of hospital stay, and weight gain parameters together are sparse. Therefore, in an effort to examine the effect of MSS on outcome parameters like feeding performance (transition

time), duration of hospital stay, and weight gain in preterm neonates of a specific weight group, i.e., VLBW neonates (weight from 1000 g to less than 1500 g), the present study was undertaken. Besides, there is no data available in the literature from India's northeastern region, including Agartala. If found beneficial, MSS can become a cost-effective community as well as institutional level intervention for better outcomes of preterm babies.

The authors proceeded with a null hypothesis (H0) stating that the mean duration of hospitalisation, weight gain, and transition time from gavage feeding to independent oral feeding in preterm VLBW neonates does not differ significantly between those who received MSS and those who did not.

MATERIALS AND METHODS

This hospital-based quasi-experimental study was conducted from June 2021 to December 2022 in the Department of Paediatrics at Agartala Government Medical College, Agartala, Tripura, India. The Institutional Ethics Committee approved the study (vide letter number F.4 (5-244)/Academic/IEC/Certificate/2021/7136, Dated 02/06/2021).

Inclusion criteria: All neonates admitted during the study period with a gestational age from 28 weeks to less than 37 weeks and a birth weight from 1000 g to less than 1500 g were included in the study.

Exclusion criteria: Neonates with severe congenital malformations and critical illness were excluded from the study.

Sample size: By consecutive sampling, 104 eligible newborns were enrolled in the study.

Study Procedure

Upon admission, all neonates meeting the inclusion criteria were weighed and examined, and a detailed antenatal and postnatal history was recorded, including the unique hospital identification number, date and time of admission, gender, ethnicity, social class as per the Modified Kuppuswamy Socio-economic Scale-2021 [18], domicile, age on admission, gestational age on admission, weight on admission, method of feeding, whether MSS was given or not, date and time of achieving independent oral feeding, age on discharge, weight on discharge, date and time of discharge, etc. All admitted neonates underwent relevant investigations and received treatment and standard neonatal care, including KMC, as per the departmental protocol. Some of the department's faculty members administered MSS in addition to standard neonatal care and KMC for VLBW neonates. Thus, there were two groups of VLBW neonates based on the provision of MSS. Initially, MSS was provided by staff nurses, and later by the mother as soon as she felt confident after training. After thorough handwashing, MSS was provided as follows, based on previous studies [4,7,8]:

1. Auditory stimulation: Mother's voice or gentle sound from a toy for three minutes.
2. Kinaesthetic stimulation: Passive motion of limbs for three minutes.
3. Visual stimulation: Moving a red balloon over the eyes for about three minutes.
4. Vestibular stimulation: Gentle horizontal and vertical rocking for three minutes.
5. OMS: Gentle stroking of lips, gums, and cheeks with a sterile cotton bud for three minutes.
6. Tactile stimulation: Gentle massage with moderate pressure for 15 minutes in a sequence of chest, upper limbs, and lower limbs, first in the supine position, and then in the prone position. The infants were given 15 minutes of massages three times per day. Each 15-minute massage session consisted of three standardised five-minute phases. Tactile stimulation was given during the first and third phases, and kinaesthetic stimulation was given during the middle phase [7,8].

Neonates were discharged when they could maintain vital parameters, and independent oral feeding was established.

All the enrolled neonates were followed-up until discharge. Daily weight records and detailed feeding records were maintained separately. All collected data were recorded in the abstraction form before the discharge of each enrolled newborn.

STATISTICAL ANALYSIS

All the preterm and VLBW neonates included in the study were divided into two groups based on the provision of MSS. Demographic data were displayed in a frequency distribution table. Mean and standard deviation were determined in both groups for the duration of hospitalisation, weight gain, and transition time from gavage to eight independent oral feedings. The normality of data distribution was determined by histograms, skewness, and kurtosis values. The significance of the difference of proportion and mean was tested by Chi-square and Mann-Whitney U tests, respectively, in Statistical Package for Social Sciences (SPSS) software version 26.0. The difference was considered significant for a p-value <0.05. From the study design, plausible confounders were identified, and their effect was studied by linear regression analysis.

RESULTS

A total of 104 newborns were enrolled in the study. There were 68 (65.38%) neonates from rural areas and 27 (26%) neonates from tribal (indigenous) population. Social class-wise, 44 (42.30%) newborns were from the upper-lower socio-economic class of the Modified Kuppuswamy scale. In terms of weight, 27 (26%) neonates were ≤1.25 kg and 77 (74%) were >1.25 kg to <1.5 kg. The mean gestational age of neonates was 32.04±1.75 and 32.679±1.19 weeks in the MSS-given and MSS-not given groups, respectively. The M:F ratio of neonates was 1.43:1 and 1.30:1 in the MSS-given and MSS-not given groups, respectively. Demographically, both groups did not differ significantly except in terms of domicile [Table/Fig-1].

The mean duration of hospital stay in the MSS-given group was 16.10±9.181 days, compared to 11.42±6.197 days in the MSS-not given group. The mean weight gain in the MSS-given group was 97.00 grams (SD=123.09362 grams), as opposed to -23.41 grams (SD= -43.96390 grams) in the MSS-not given group. The mean transition time in the MSS-given group was 9.47 days (SD=5.17 days), compared to 9.89 days (SD=4.70 days) in the MSS-not given group [Table/Fig-2].

Based on the Skewness, Kurtosis statistic, and histogram [Table/Fig-3], it was evident that the distribution of the duration of hospital stay in both categories of MSS deviated substantially from normal distribution. Therefore, a nonparametric Independent samples Mann-Whitney U Test was conducted to determine the significance of the difference in the mean duration of hospital stay in both groups. The test indicated that the mean duration of hospital stay across the groups differed significantly. (Mann-Whitney U=925.000, n1=51, n2=53, Z=-2.778, p=0.005, two-tailed). Therefore, there was a significant increase in the mean duration of hospitalisation in the MSS-given group compared to the MSS-not given group. Hence, MSS was not beneficial in reducing the duration of hospitalisation in preterm VLBW neonates.

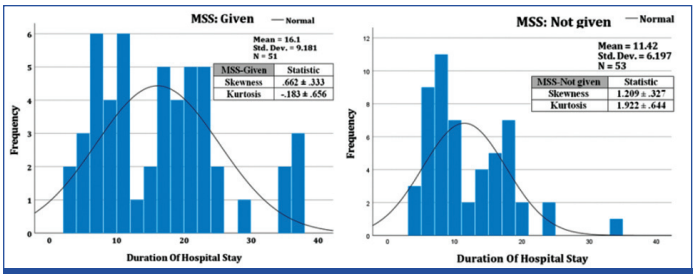
Similarly, the Skewness, Kurtosis statistic, and histogram showed that the distribution of weight gain in both categories of MSS deviated from normalcy [Table/Fig-4]. Consequently, a nonparametric independent-samples Mann-Whitney U Test was performed to determine the significance of the difference in mean weight gain in both groups. The test indicated that the mean weight gain across the groups of MSS differed significantly. (Mann-Whitney U=247.000, n1=51, n2=53, Z=-7.187, p<0.001, two-tailed). Therefore, there was a significant increase in mean weight gain in the MSS-given group compared to

Variables		Count (%) (N=104)	†MSS (%) given (N=51)	†MSS (%) not given (N=53)	Two-tailed p-value	Test
Age	≤3 days	101 (97.12)	48 (94.1)	53 (100)	0.201	Chi-square‡
	>3 days to 28 days	3 (2.88)	3 (5.9)	0		
Gender	Male	60 (58)	30 (58.8)	30 (56.6)	0.976	
	Female	44 (42)	21 (41.2)	23 (43.4)		
Domicile	Rural	68 (65.38)	28 (54.9)	40 (75.5)	0.039	
	Urban	36 (34.62)	23 (45.1)	13 (24.5)		
Ethnicity	Tribal (Indigenous)	27 (26)	15 (29.4)	12 (22.6)	0.573	
	Non tribal	77 (74)	36 (70.6)	41 (77.4)		
Weight	≤1.25 kg	27 (26)	18 (35.3)	9 (17.0)	0.057	
	>1.25 Kg to <1.5 Kg	77 (74)	33 (64.7)	44 (83)		
Social class#	Upper	3 (2.90)	1 (2.0)	2 (3.8)	0.974	
	Upper middle	4 (3.80)	2 (3.9)	2 (3.8)		
	Lower middle	24 (23.10)	11 (21.6)	13 (24.5)		
	Upper lower	44 (42.30)	22 (43.1)	22 (41.5)		
	Lower	29 (27.90)	15 (29.4)	14 (26.4)		
Mean gestational age	-	-	32.04±1.75	32.679±1.19	0.022	Mann-Whitney U test

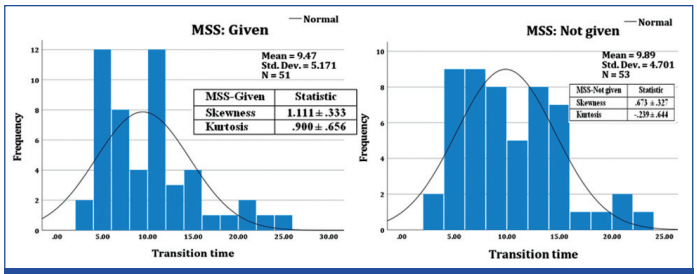
[Table/Fig-1]: Demographic profile.
‡Continuity adjusted by Yates's correction. #As per modified Kuppuswamy socio-economic scale- 2021 [18]; †Multimodal sensory stimulation

Parameters (mean±SD)	At admission		At discharge		Mann-Whitney U test
	MSS-given	MSS-not given	MSS† given	MSS† not given	Two tailed p-value
Duration of hospital stay (Days)	0	0	16.10±9.181	11.42±6.197	0.005
Weight (Kg)	1.30431±0.145	1.40908±0.123	1.40128±0.155	1.39428±0.126	-
Transition time (Days)#	0	0	9.47±5.171	9.89±4.701	0.460
Weight gain (Grams)	-	-	97.0000±123.09362	-23.4151±43.96390	<0.001

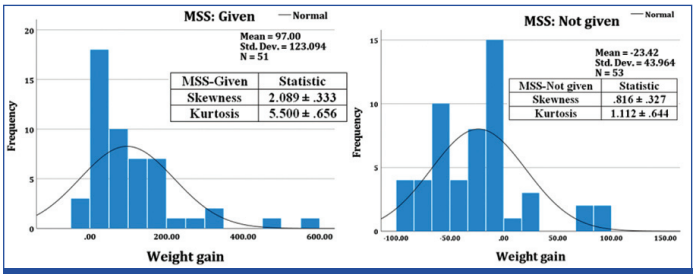
[Table/Fig-2]: Outcome parameters.
#Time taken in days from gavage feeding to 8 independent oral feeding; †Multimodal Sensory Stimulation



[Table/Fig-3]: Duration of hospital stay.
*MSS: Multimodal sensory stimulation



[Table/Fig-5]: Transition time.
*MSS: Multimodal sensory stimulation



[Table/Fig-4]: Weight gain.
*MSS: Multimodal sensory stimulation

the MSS-not given group. Thus, MSS was clearly beneficial in terms of weight gain in preterm and VLBW neonates.

Furthermore, the Skewness, Kurtosis statistic, and histogram [Table/Fig-5] revealed that the transition time in both categories of MSS was not normally distributed. Therefore, a nonparametric independent-samples Mann-Whitney U Test was conducted to determine the significance of the difference in mean transition time in both groups. The test showed that the mean transition time across the groups did not differ significantly. (Mann-Whitney U=1464.500, n1=51, n2=53, Z=0.738, p=0.460, two-tailed). Thus, MSS was not beneficial in reducing the mean transition time from gavage to independent oral feeding in preterm VLBW neonates.

Two variables, duration of hospitalisation, and gestational age on admission, were identified from the study design as plausible confounders of weight gain. Linear regression was used to test if the duration of hospital stay and period of gestation could significantly predict weight gain. The fitted regression equations were: Weight gain=4.17E-14+7.31×(duration of hospital stay) and Weight gain=2E-14-4.66×(period of gestation). The overall regression was statistically significant (R2=0.328, F (2, 101)=24.649, p<0.001). It was found that the duration of hospitalisation significantly predicted weight gain (β=0.542, p<0.001) and the period of gestation did not significantly predict weight gain (β=-0.065, p=0.476) [Table/Fig-6]. Thus, the duration of hospitalisation was found to be a potential confounder of weight gain.

DISCUSSION

The present study was a quasi-experimental study involving 104 VLBW neonates with gestational ages from 28 weeks to less than 37 weeks. In the study, 51 neonates received MSS, while 53 neonates did not. The study by Thabet AM and Sayed ZA enrolled neonates with gestational ages from 30 to 34 weeks, while the studies by Govindarajan K et

Model summary								
					Change statistics			
Model	R	R2	Adjusted R2	SE of estimate	R2 change F change	df1	df2	Sig.
1	0.573a	0.328	0.315	90.66430	0.328 24.649	2	101	<0.001
a. Predictors: (constant), duration of hospital stay, period of gestation								
ANOVAa								
Model		Sum of squares	df	Mean square	F	Sig.		
1	Regression	405222.689	2	202611.344	24.649	<0.001b		
	Residual	830221.465	101	8220.015				
	Total	1235444.154	103					
a. Dependent variable: weight gain								
b. Predictors: (constant), duration of hospital stay, period of gestation								
Coefficientsa								
		Unstandardised coefficients		Standardised coefficients				
Model		B	Std. Error	Beta	t	Sig.		
1	(Constant)	87.152	218.484		0.399	0.691		
	Period of gestation	-4.658	6.507	-0.065	-0.716	0.476		
	Duration of hospital stay	7.315	1.219	0.542	5.999	<0.001		

[Table/Fig-6]: Regression analysis.
a. Dependent Variable: weight gain. ANOVA: Analysis of variance

al., and Arora K et al., enrolled neonates with gestational ages from 28 to 32 weeks [10,11,15]. Alice JJ et al., included neonates of 28 to <37 weeks of gestation weighing between 1 and 2.5 kg [12]. Rangey PS and Sheth M studied newborns <37 weeks weighing below 2.5 kg [16]. Thus, there are minor demographic differences between the present study and the studies available in the literature.

In the present study, neonates receiving MSS had a significantly prolonged hospital stay compared to neonates without MSS. Thus, MSS was not beneficial in reducing the duration of hospitalisation among preterm VLBW neonates. Fucile S et al., in their study, observed that combined oral and non-oral sensorimotor interventions did not decrease the duration of hospitalisation [7], whereas Govindarajan K et al., observed that combined modalities of prefeeding stimulation resulted in a shorter duration of hospitalisation in preterm babies [11]. Additionally, Zhang Y et al., studying the effect of combined non-nutritive sucking and oral stimulation, observed that there was no difference in the duration of hospitalisation between the intervention and control groups [13]. Bragelien R et al., experimenting with OMS, also had similar observations [17]. On the contrary, the study of Thabet AM and Sayed ZA observed that OMS decreased hospital stay among the preterm neonates [10]. Similarly, Rangey PS and Sheth M also noted a significant reduction in the duration of hospital stay in preterm low birth weight neonates following massage therapy and KMC [16]. In the present study, in the MSS given group, 33.3% of infants had a gestational age of less than 32 weeks, as opposed to 15.1% in the MSS not given group. This might have played a confounding role, leading to a prolongation of the length of hospitalisation in the MSS given group.

Another important observation of the present study was that preterm VLBW neonates with MSS significantly gained more weight compared to the neonates without MSS. Modi K et al., in their study, found that preterm infants in the experimental group had shown better weight gain than those in the control group following multisensory interventions [9]. Alice JJ et al., also observed a significant increase in mean weight gain in the experimental group following Tactile-Kinaesthetic stimulation compared to the control group [12]. Thabet AM and Sayed ZA and Rangey PS and Sheth M observed that OMS and massage therapy with KMC, respectively, led to better weight gain in preterm infants [10,16]. However, Fucile S et al., concluded that combined sensorimotor interventions did not lead to improved weight gain in preterm infants [7]. Similarly, there was no statistically significant difference in the daily weight gain between the experimental and control groups following combined modalities of prefeeding stimulation in the study of Govindarajan K et al., [11]. Likewise, no significant weight gain was observed by Zhang Y et al., and Aliabadi F and Askary RK following tactile-kinaesthetic stimulation and non-nutritive sucking with oral stimulation, respectively [13,19].

In the present study, it was also noted that preterm and VLBW neonates with MSS did not have an early transition from gavage to independent oral feeding when compared to neonates without MSS. This result was analogous to the study conducted by Govindarajan K et al., who observed that combined modalities of sensorimotor interventions did not significantly alter the transition time [11]. On the contrary, Fucile S et al., observed that combined sensorimotor interventions (oral and non-oral) led to attainment of independent oral feeding sooner than preterm infants who received no such interventions [7]. However, following OMS only, no reduction in transition time from gavage to oral feeding was observed by Bragelien R et al., [17]. But, reduction in transition time following OMS was observed in the studies conducted by Bala P et al., Thabet AM and Sayed ZA Zhang Y et al., and Arora K et al., [5,10,13,15].

Two variables, duration of hospitalisation and gestational age on admission, were considered possible confounders of weight gain. Linear regression analysis identified the duration of hospitalisation as a potential confounder of weight gain. However, to control the effect of confounders, a double-blinded RCT is necessary. Therefore, this was beyond the scope of the present study design. The study of Modi K et al., described gender and age as possible confounders in their study but did not analyse their effect [9]. Discussion on confounders in available literature is scarce.

Finally, it might be worth mentioning that positive weight gain was almost uniformly seen in most of the recent studies [Table/Fig-7] [10-12,15,16]. despite differences in the mode of stimulations. However, their impact on the duration of hospitalisation and transition time varied from study to study.

Limitation(s)

The present study was a small sample quasi-experimental study inherently prone to random error. Besides, the non-probability sampling method of the present study makes it non-generalisable. In addition, the present study was an open-label study prone to selection bias and detection bias. Long-term effects of MSS were

Parameters		Thabet AM and Sayed ZA [10]	Govindarajan K et al., [11]	Alice JJ et al., [12]	Rangey PS and Sheth M [16]	Arora K et al., [15]	Present study
Place of study		Egypt	Puducherry	Karnataka	Gujarat	Maharashtra	-
Year of study		2021	2018	2019	2013	2018	June 2021 to Dec 2022
Number of participants		60	60	40	30	30	104
Sampling method		Simple randomisation	Simple randomisation	Simple randomisation	Simple randomisation	Simple randomisation	Consecutive sampling
Study design		RCT	RCT	RCT	RCT	RCT	Quasi-experimental
Demographic features	Gender	-	-	-	-	-	1.36:1
	Gestation age	30 to 34 weeks	28 to 32 weeks	28 to <37 weeks	<37 weeks	28 to 32 weeks	28 to <37 weeks
	Weight	-	-	1 kg - 2.5 kg	<2.5 kg	-	1 kg to <1.5 kg
	Stimulation (Intervention)	Oral motor stimulation	Combined sensorimotor stimulation	Tactile and kinaesthetic stimulation	Massage therapy and KMC	Oromotor Stimulation (OMS)	Multimodal sensory stimulation
Effect of stimulation on WG[$]		Positive	Nil	Positive	Positive	Positive	Positive
Effect of stimulation on DHS[#]		Positive	Positive	Nil	Positive	Nil	Nil
Effect of stimulation on TT[*]		Positive	Nil	Nil	Nil	Positive	Nil
External validity[‡]		Positive	Nil	Nil	Nil	Nil	Nil

[Table/Fig-7]: Comparison with some recent studies [10-12,15,16].
[$]Weight gain; [#]Duration of hospital stay; [*]Transition time; [‡]The extent to which findings of the study can be applied to other people/community/real world

not evaluated in the study. Moreover, the duration of hospital stay was found to be a potential confounder of weight gain.

CONCLUSION(S)

In the present study, authors concluded that MSS is beneficial for promoting weight gain in preterm VLBW neonates. However, it was observed that MSS was not helpful in reducing the duration of hospital stay and the transition time from gavage feeding to oral feeding. Nevertheless, the authors also noted that MSS was a cost-effective, non-pharmacological method that could be easily taught to the family members of preterm neonates and has the potential to be considered as both a community and institutional-level intervention for promoting the growth of preterm VLBW neonates. Therefore, a multicentre double-blinded RCT involving a large sample with matched groups and a more standardised stimulation protocol is needed in the future to confirm the role of MSS in preterm VLBW neonates.

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