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Original Article

Effects of Progressive Resistance Exercise Training on Endurance and Functional Mobility in Children with Spina Bifida

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ABSTRACT

Background: Spina bifida has been known as a neurological disorder characterized by common problems that are associated with lower extremities usually having issues with their movement, strength and performing activities of daily living. A lot of practices are carried out on children with spina bifida to help them regain their normal performance. Progressive resistance exercises are applied to children with spina bifida to help them gain power by making them capable of performing movements and their daily tasks and activities. **Objective:** To assess the effects of progressive resistance exercise training on functional mobility and endurance in children with spina bifida. **Methods:** Our study is a randomized controlled trial which was conducted in the Children's Hospital, Lahore. The sample size for this study was calculated to be 20 using the two-proportion mean formula. The sampling technique employed was a non-probability convenience sampling technique to recruit children with spina bifida in our study. Two groups were made one was Group A, the experimental group which received the progressive resistance exercises while Group B, the conventional group received only simple active and passive range of motion exercises of lower extremities. The tool employed was the Patient Specific Scale while the data was collected and measured before and after treatment for both groups. **Results:** The results of the current study showed significant results in both the groups but Group A received Progressive Resistance Exercises showed statistically significant results within the group having a significant p-value=0.000. Group A showed an increase in its mean score of sit-to-stand by 7.00±2.62 whereas Group B showed an increase in the mean score of sit-to-stand by 5.7±2.90. Group A showed statistically more significant results. For walking, Group A showed an increase in mean score by 6.4±2.83 whereas Group B showed a score of 5.00±3.26. **Conclusion:** According to the results of the study, both treatment approaches of progressive resistance exercises and conventional exercises were effective but Group A, receiving the progressive resistance exercise training showed more significant differences in mobility and daily activities when compared with Group B, receiving only conventional exercise treatment.

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INTRODUCTION

The spinal cord is known as the association between the brain and other parts of the body that have been connected through the peripheral nervous system. Lumbar puncture has been used as a diagnostic procedure to assess the spinal cord. This procedure is performed by collecting the fluid named cerebrospinal fluid to measure the inflammation, infection and intracranial pressure which is observed in different conditions such as Subarachnoid hemorrhage, Alzheimer's disease, Gullianbarre syndrome, meningitis and multiple sclerosis.[1]

Numerous diseases and disorders have been associated with the vertebral column, either its appearance of alternations in its functions that might be congenital, accidental or because of degenerative changes. One of the most common spinal diseases is Spina Bifida. It has been defined as the incomplete closure of the spinal cord. It has various types and levels of severity.[2] Spina bifida is an inborn disorder that is associated with defects during the development of the spine before the birth of the child. It also comprises defects associated with the neural tube. Spina bifida has been also known as a split spine due to incomplete formation of the spine. The immature and incomplete development of the neural tube causes numerous issues in the body. Naturally, the neural tube forms during the beginning of the pregnancy and further develops to form the brain and spinal cord and its development is completed in almost 1st month of the pregnancy. But when considering spina bifida the neural tube does not close fully and it tends to have a gap in the spine that eventually brings a lot of various problems in the baby.[3] Spina bifida is detected by conducting an ultrasound during pregnancy. One other commonly used detection method is an anomaly scan which is performed on pregnant females for ruling out such problems in 2nd trimester. Levels of proteins are tested from the fluid taken from the uterus by amniocentesis to rule out spina bifida.

The blood test is also conducted to check the levels of alpha-fetoprotein to diagnose issues during pregnancy as its increased levels are an indication that the baby is developing spina bifida.[4] Spina bifida is of numerous types and its severity depends on its types, it might be mild, moderate and severe. Individuals who are affected by spina bifida might have minor symptoms or they can also seek medical treatment for their entire life.[5] One type is Spina bifida occulta, individuals suffering from this type do not show specific symptoms as the majority of them don't even know that they have this underlying disease. In some cases, a tuft of hair or a dimple has been observed at the back of the patient. The second type is spina bifida meningocele, in this type, meninges protrude out from the gap that has not been properly developed in the spine. The third type is Spina bifida Myelomeningocele, the most complex and severe type of spina bifida which involves the protrusion of spinal nerves and protective membranes. In the majority of cases higher extent of neurological issues have been observed that might lead to complete damage either physically or it might depend on the extent of the problem.[6] Same as all other congenital diseases and conditions spina bifida shows some specific signs and symptoms but again it depends on the type and extent of the disease.

The sufferers might present themselves with delays in their milestones, gross and fine motor activities, weakness of lower limbs and in some extreme cases complete flaccid paralysis of lower limbs might also be present. Structural alternations such as scoliosis and kyphosis, bowel and urinary incontinence, contractures in joints, loss of sensations in lower limbs, problems with skin, latex allergy and hydrocephalus might also be associated

with spina bifida.[7] Rehabilitation plan and physical therapy play a very beneficial role in overcoming and minimizing motor deficits by preventing further deformities, enhancing weight-bearing activities for good bone health, assessing disturbances in tone and sensations, promoting movement by making muscles strong and focusing on milestones in patients with spina bifida.[8]

Various approaches of physical therapy treatment have been applied on patients with spina bifida to bring them towards normal daily living, to improve their movements, to develop strength and to maintain balance. To prevent the formation of new contractures and to break down the already-made contractures passive range of motions is used. Passive range of motion helps in maintaining the flexibility of joints, especially in patients who cannot ambulate independently.[9] This protocol aids in subsiding the restriction developed in performing movements and might also require devices for performing activities of daily living. Range of motion is encouraged instead of using assistive devices to progress the lower extremity support and ambulation as a range of motion exercises have a better impact on the child by employing surroundings and results in positive feedback. While considering the case of infants, normal milestones are achieved by employing challenging exercises and movements.[10]

Physical therapy interventions are highly prescribed for numerous diseases for all age groups in various durations to avoid the severity of symptoms and sedentary routines. Aerobic training exercise sessions, progressive resistance exercises and strength training exercise plans for upper and lower extremities are functional and applicable to patients according to their disorders.[11] When progressive resistance exercises are applied to individuals suffering from neurological disorders it represents effectiveness as the targeted progressive resistance plans tend to strengthen the lower limbs and it also enhances the functioning when we are trying to attain maximum advantages from these customized plans.[12]

Resistance training exercises might easily be applied and practiced on children and adults who have any kind of musculoskeletal disorders as it does not tend to harm the weak joints and muscles or even those who are suffering from spasticity. These progressive resistance exercises have a very positive influence and impact on the mental state of individuals and move them towards improvement and betterment.[13] The most substantial benefit of resistance exercise training is its capability and ability to prevent the occurrence of fractures, because of resistance exercises the weakened muscles gain so much strength that they get a perfect grip when a joint or any other structure of the body is moving in any direction or performing any other pattern of movement.[14] Along with these exercises some other activities might also be performed to make the patient fit in all the aspects. Aerobic functional capacity is substantial for measuring muscular strength. The ambulatory performance is measured by performing a minute walk test in which the maximum distance that an individual covers in six minutes while utilizing normal aerobic functioning. It has been used in individuals with Spina Bifida and its results depend on the severity of the disease.[15]

Similarly, to stand test is performed during these exercise sessions to assess the strength of the lower extremity and also to check the balance of the body.[16] Resistance training exercises have been known to bring improvements in muscular strength that eventually have a progressive and positive effect on the mobility of the sufferer. The progressive resistance exercise training programs are specifically customized to build

force and power in the muscles that have been weakened. These programs allow the weakened muscles to perform an extra effort to gain strength and efficacy in movements.[17,18] Our current study was conducted to determine the endurance power and functional mobility of children with spina bifida by employing progressive resistance exercises in the lower limbs. Countries like Pakistan, which are still developing and have limited resources need to find cheaper and easier ways to treat complex disorders like spina bifida. Our current study would add authentic evidence to prove the benefits of progressive resistance exercises in children with spina bifida.

METHODS

Our current study is a Randomized Controlled Trial and data for this study was collected from the Rehabilitation center of The Children's Hospital, Lahore, Pakistan. Our study was completed within ten months after the approval of its synopsis. The sample size for our study was calculated using the two-proportion mean formula. The total sample size (both groups) was 20 and after adding a 10% attrition rate sample size became 22. The calculated sample size was twenty children with spina bifida in both the groups used in this study. The total sample size was also calculated by employing Epitool software by using a confidence level of 95% and power of 85% taken from a previously conducted study. After adding a 10% attrition rate the sample size came out to be ten in each group.[19] The sampling technique employed was a non-probability convenience sampling technique to recruit the sample size in our study. Only those children with Spina Bifida were recruited in our study who were able to follow the commands and were easy to handle. The age limit was eight to sixteen years. Both genders were recruited in our study. Children having a manual muscle testing score of less than three of their lower extremity weakness and hip and children with hip and knee flexion contractures were recruited in our study.[20] Children aged less than eight years, children who were completely paralyzed (absent tone) and children with bone fractures were not recruited in our study.[21] The tool employed for this study was the Patient Specific Functional Scale.[22] This is a self-reporting outcome measure of function that might be used in patients who have fluctuating levels of independence. The main objective of this tool is to provide aid to clinicians with a reliable, valid, and efficient outcome measure that might be easy to use and could apply to a larger number of clinical expositions. This scale can be used for a huge variety of neurological and musculoskeletal conditions.[23] The data was analyzed by employing a statistical package for social sciences version 23.

All the quantitative variables were represented in the form of mean and standard deviation accompanied by its range from maximum to minimum while all the qualitative variables were represented in the form of frequency tables and percentages. Non-parametric and parametric tests were also applied for checking the data. Frequency tables and bar charts were used to represent the descriptive statistics. Differences between the pre and post-intervention of both the groups were checked by paired sample t-test. Independent sample t-test was employed to verify the difference between the groups. The patients who met the set inclusion and exclusion criteria were allocated to their respective groups. The patients were selected from The Children's Hospital, Lahore. All the recruited subjects were randomly divided into 2 equal groups. Written consent form in Urdu and English was given to all the participants before their recruitment in this study. The participants were randomized by employing a computer-generated method.[24] The patients were allocated into Group A and Group B by employing the sealed envelope method.[25] For

assigning parallel assignment[26] was employed. Our study was single-blinded. The assessor was uninformed of the intervention provided to both groups. Group A was the experimental group that received progressive resistance exercises.[27] These progressive resistance exercises included flexion, extension, adduction and abduction of the hip and flexion and extension of the knee, which had minimum time in the starting and minimum quantity of loads. Loads were provided by thera bands and sandbags. Minimum resistive exercises were employed starting with minimum time which eventually led to an increase in forces and time that would eventually increase the strength of the muscles of the lower extremity.

The increase in the strength of the muscles of the lower extremity would aid in improving the contractures built in the lower extremity and would also aid in ambulation and functional mobility of the patients. Our tool, patient patient-specific functional scale was employed to assess functional mobility and ambulation in children with spina bifida. The 6-minute walk test[28] and sit-to-stand test[29] were also employed to assess the endurance and cardiac conditioning in children with spina bifida.[30] Group B which was the conventional group received only simple active and passive range of motion exercises of the lower extremity with positioning for assistive devices.

RESULTS

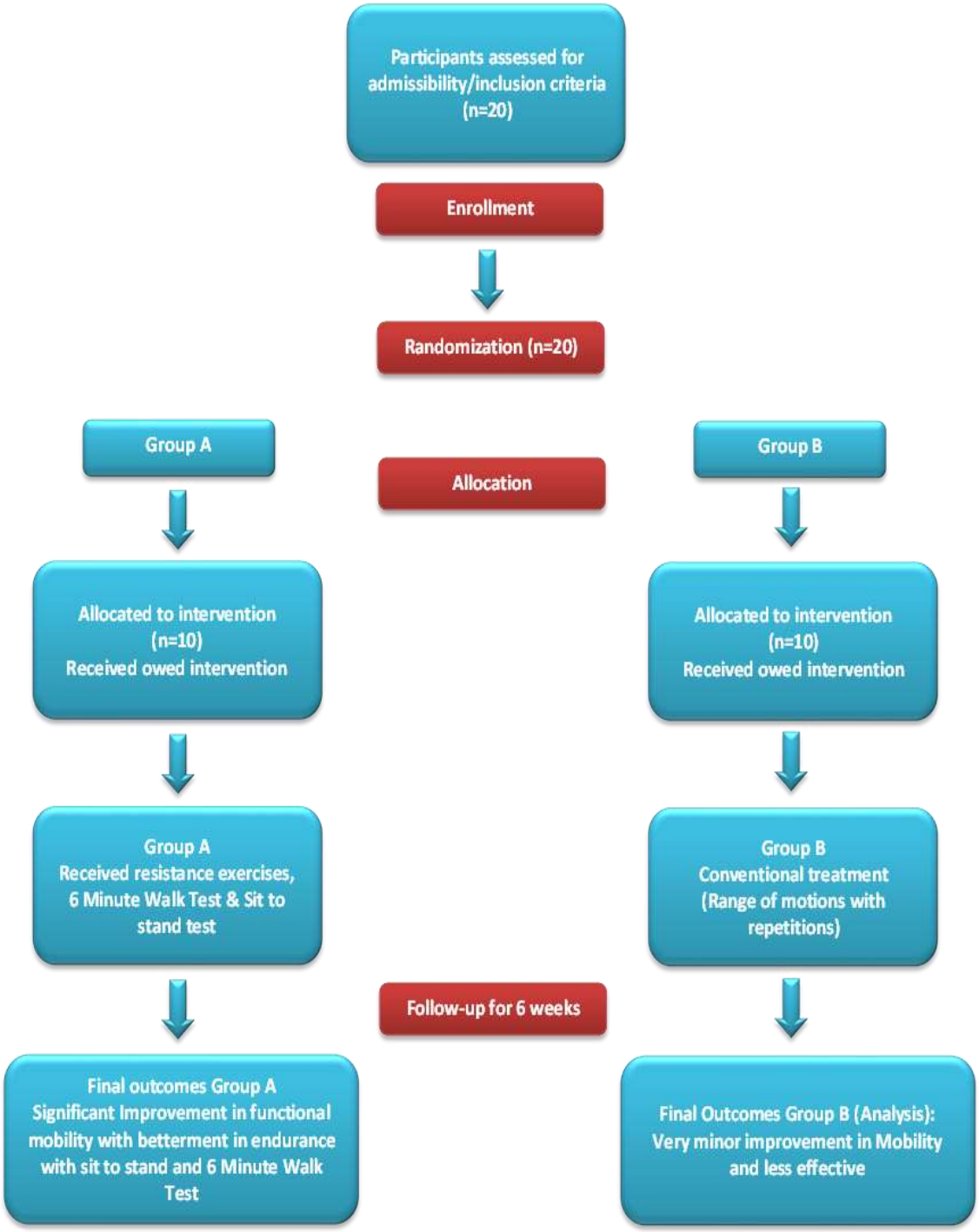
Considering the inclusion and exclusion criteria, 20 patients with spina bifida were selected to be recruited in our current study. 10 children with spina bifida were allocated to group A who received progressive resistance exercise and 10 children with spina bifida were allocated to group B who received conventional treatment. Results of our current study showed that the mean age for group A was 10.6 years and the mean age for group B was 10.8 years. We assessed the children from both groups by employing Patient Specific Functional Scale, before and after treatment. We checked the results before the treatment which showed us that in both the groups the patients had low functional mobility and endurance. We checked the results again after the treatment as per protocols. After analyzing and observing all the variables we applied the paired and independent sample t-test to evaluate the statistical difference of post-treatment in both the groups which showed us that a p-value of 0.000 means that there is a significant difference between both the groups and on that basis we rejected our null hypothesis.

For between the groups analysis independent sample t-test was employed. There was no statistically significant difference found across the groups at baseline as p-values were greater than 0.05. For within-group analysis paired sample t-test was employed. There was a statistically significant difference in group A which received progressive resistance exercise as the p-value was less than 0.05 while it was non-significant for group B having a p-value more than 0.05. Table 1 of normality shows us that our data was normally distributed because the p-value was more than 0.05, which was considered to be normal. Between the groups analysis independent sample t-test was employed. There was no statistically significant difference found across the groups at baseline as p-values were greater than 0.05. For within-group analysis paired sample t-test was employed. There was a statistically significant difference in group A which received progressive resistance exercises as the p-value was less than 0.05 while it was not significant for group B having a p-value of more than 0.05.

DISCUSSION

The major aim of our current study was to determine the effects of progressive resistance

Figure 1: CONSORT Flow Diagram



exercises on the functional mobility and endurance of children suffering from spin bifida. When we analyzed the outcome measures of our study, we found out that there was significant improvement in both our groups but group A which received progressive resistance training exercise showed more improved and better results in

Table 1: Normality Test

Pre-intervention score of Lying to sitting	.176	20	.106	.917	20	.088
Pre-intervention score of Knee march	.200	20	.035	.941	20	.250
Pre-intervention score of Sit to stand	.147	20	.200*	.921	20	.101
Pre-intervention score of Foot lift	.184	20	.074	.930	20	.155
Pre-intervention score of Step up	.154	20	.200*	.934	20	.182
Pre-intervention score of Walk	.111	20	.200*	.946	20	.315

Table 2: Between and Within Group Comparison of Walk

Variable Walk	Group A Mean±SD	Group B Mean±SD	Mean Difference	p-value
Pre-treatment	5.40±2.63	4.60±3.06	.800	.539
Post-treatment	6.40±2.83	5.00±3.26	1.40	.320
Mean difference	1.00	.400		
p-value	.003	.061		

Table 3: Between and Within Group Comparison of Sit-to-Stand

Variable: Sit to stand	Group A Mean±SD	Group B Mean±SD	Mean Difference	p-value
Pre-treatment	6.00±2.26	5.40±2.83	.600	.607
Post-treatment	7.00±2.62	5.70±2.90	1.30	.308
Mean difference	1.00	.300		
p-value	.005	.081		

betterment of functional mobility and endurance when compared with the other group which received only conventional physical therapy treatment. Our current study conducted follow-up only for 6 weeks but our study recommends that if these plans had gone more follow-ups for more than six weeks then the results would have been more significant. So, our current study recommends future researchers conduct studies for a longer period of follow-ups for more authentic evidence. Baym and co-workers conducted a study to

Figure 2: Histogram of Weight for Group A

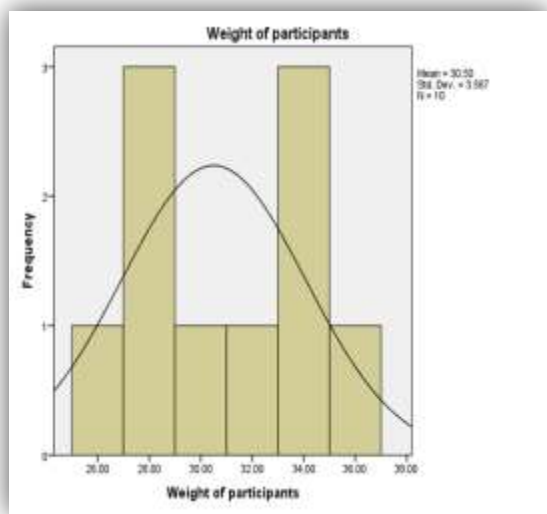
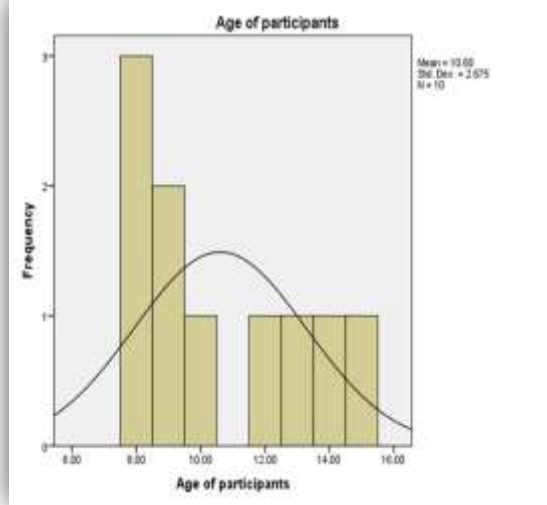


Figure 3: Histogram of Age for Group A



determine whether functional mobility improves after intensive resistance exercise in an adolescent with spina bifida. They aimed to elaborate on the uses, benefits and effectiveness of a novel intensive progressive resistance exercise approach to address the functional goals of a fourteen-year-old adolescent with myelomeningocele (a type of spina bifida). Their results showed us that the child demonstrated improvements in its speed of gait, functional strength of lower extremities and walking endurance.[23] Their results coincide with the results of our study. Kirsten Legerlotz and co-workers conducted a study to determine the effects of resistance training on the health of children and adolescents suffering from disabilities.[31] Their study and our study observed that many parents still hesitate to encourage their children to take part in resistance training programs. This is unfortunate since recent studies have shown that resistance training affects children's health positively. They aimed to present an overview of the health-associated effects of resistance training exercises on children and adolescents with various disabilities.[31] Their aim and our aim coincide with each other. Their review emphasized that when compared with other types of treatments resistance training is observed to be without any adverse effects. Our study agrees with this since progressive resistance training also didn't show any adverse effects. Our current study and a review conducted by Theresa suggest that further studies are needed to investigate lifestyle interventions that might facilitate physical activity and exercises and to determine the required amount of exercise to reduce the secondary conditions when children with spina bifida grow older.[32]

Liese and co-workers conducted a systematic review to determine the effects of electrical stimulation, motor skills training and exercise training on the strength of children with meningomyelocele. Their review provided a critical synthesis of research regarding their aim. They concluded that there was limited evidence suggesting improvements in strength when using these interventions and much of the evidence was of low methodological quality.[33] So, their review and our current study suggest that further studies are needed which have high methodological quality. Their study and ours both suggest that further

Figure 4: Histogram of Age for Group B

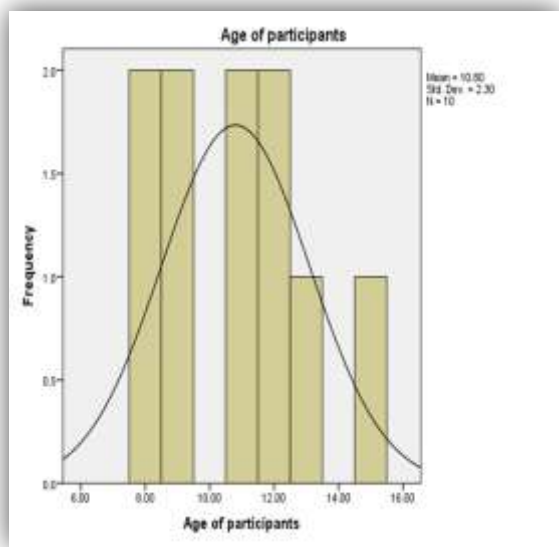
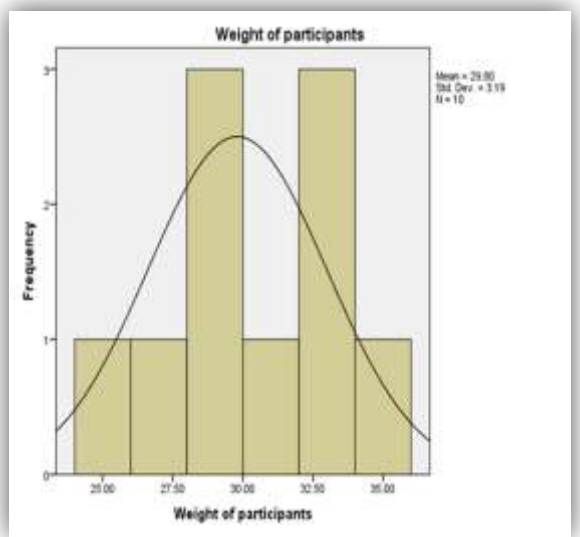


Figure 5: Histogram of Weight for Group B



studies need to be conducted regarding various strength training interventions for children with spina bifida. Our study had a limited number of sample size. Future researchers are recommended to determine the effects of progressive resistance exercises on a larger Pakistani population for more generalizable results. Developing countries like Pakistan need more studies as evidence to provide the society to treat disorders like spina bifida in more economical ways.

CONCLUSION

We conclude that progressive resistance exercises might be employed as a regular plan while treating children with spina bifida for better mobility and endurance outcomes of the children with spina bifida.

DECLARATIONS

Consent to participate: Written consent had been taken from patients. All methods were performed following the relevant guidelines and regulations.

Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.

Competing interests: None

Funding: No funding source is involved.

Authors' contributions: All authors read and approved the final manuscript.

CONSORT Guidelines: All methods were performed following the relevant guidelines and regulations.

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