Original Research Article

Effect of Rebounding Exercises Versus Whole Body Vibration on Children with Down Syndrome

Abstract

Aim: To compare between the effects of rebounding exercise and whole body vibration on functional capacity, genu recurvatum angles and bone mineral density in children with Down syndrome.

Study design: Prospective, randomized controlled study

Place and Duration of Study: National Institute for Neuro-Motor System between June 2014 and September 2014

Methodology: Thirty children (16 boys, 14 girls; age range 6-8 years) with Down syndrome . They were assigned randomly into two equal study groups. Study group I received rebounding exercise and study group II received whole body vibration. In addition, the two groups received the same designed exercise program. Functional capacity via 6-minute walk test, genu recurvatum angles and bone mineral density were evaluated before and after 3 successive months of treatment.

Results: Significant improvement was observed in the two groups when comparing their pre and post treatment mean values of all measuring variables. Functional capacity (350 ± 8.45, 357.33 ± 13.74) for study group I and II respectively. Right genu recurvatum angles were (17.80 ± 1.70, 17.60 ± 1.55); left angles were (16.13 ± 1.89, 15.07 ± 1.22) for study group I and II respectively. Bone mineral density of femoral neck (0.80 ± 0.04, 0.83 ± 0.07); distal tibia (0.48 ± 0.10, 0.55 ± 0.08); proximal tibia (0.78 ± 0.05, 0.83 ± 0.08) for study group I and II respectively ($p < 0.05$). Also, significant differences were recorded in genu recurvatum angle when comparing the post treatment results of the two groups in favor of the study group II ($p < 0.05$).

Conclusion: both whole body vibration and rebounding exercises are effective in correcting genu recurvatum, low mineral density and decreased functional capacity for children with Down syndrome. But the whole body vibration is more effective than rebounding exercise regarding to correction of genu recurvatum angle.

Key words: *Rebounding exercise, Whole body vibration, Bone mineral density, Functional capacity, Genu recurvatum, Down syndrome*

1. Introduction

Down syndrome (DS) is caused by the triplication of human chromosome 21 resulting in genetic dosage imbalance thought to affect several different developmental pathways. It occurs in 1 in 700-800 live births **[1]**. The child may display a variety of symptoms that indicate decreased muscle tone. Motor skills delay is often observed along with hypermobile or hyperflexible joints, decreased strength, decreased activity tolerance, poor attention and motivation **[2]**. Genu recuratum of the knee is a position of the tibiofemoral joint in which the range of motion occurs beyond neutral or 0 degrees of extension **[3]**. The genu recurvatum defined operationally as knee hyperextension greater than 5 degrees. It is classified to: less than 15 degrees (physiological, asymptomatic, and symmetric), and more than 15 degrees (pathological, symptomatic, and asymmetric). Uncontrolled locking of the knee during standing and ambulation causes recurrent microtrauma which leads to degenerative changes and instability **[4]**. Studies that evaluate bone density in DS are limited, and many are small case series in pediatric and adult populations who live either in the community or in residential institutions. Several environmental and hormonal factors contribute to low bone mineral density (BND) in such patients. Muscle hypotonia, low amounts of physical activity (PA), poor calcium and vitamin D absorption, hypogonadism, growth retardation and thyroid dysfunction contribute to substantial impairments in skeletal maturation and bone-mass accrual **[5]**. Children with DS experience several barriers to participate in daily PA like transportation restrictions, low motivation and lack of integrated program options **[6]**. Consequently, low levels of PA **[7]** and physical fitness **[8]** have been described in this population. Physical activity has an important role in bone mass acquisition due to its osteogenic effects **[9]**. Therefore, DS population might be considered as a population at higher risk of suffering bone fractures and osteoporosis **[10]**. Functional ability was determined by means of six minute walk test (6MWT) **[11].** This test can present an indirect assessment of someone's capacity during activities of daily living, and it can be used to follow-up evolution during treatment **[12]** and to measure walking ability and baseline cardiovascular function of people with disease or low levels of fitness **[13]**. More recently, the test has been validated in several populations, including patients with fibromyalgia, cerebrovascular accident, amputations, morbid obesity, Down syndrome, Alzheimer's disease and cerebral palsy **[14]**. In rehabilitation programs, it is a challenge to find a way to stimulate the sensorimotor system toward regaining normal voluntary movement and limb functional use. The goal of most therapy programs is to maintain the affected extremity in the best possible aligned position to avoid overstretched soft tissue, edema, and pain. Through the exercise program and use of weight-bearing techniques, the therapist attempts to maintain and improve trunk and limb alignment to allow the functional use of the extremity **[15]**. Conservative rehabilitation of genu recurvatum should be focused on more complex activities and sports- specific skills **[16]**. Rebounding is an exercise that exercises every cell in the body at once by helping the body to increase its resistive load via trampoline rebounding. The use of rebound therapy with children with both physical and learning disabilities is expanding **[17]**. Rebound therapy should be used as part of a therapy program adding to existing therapies and not in isolation the treatment program **[18]**. Rebounding from quality mini trampolines provides all the benefits of other aerobic exercise without the stress impact usually associated with vigorous activity. When exercising on the floor or jogging as vertical shock waves spread from the ankles, through bones and spine, and minor nerve damage may well occur at the root of the pelvis. Joggers often end up with micro-trauma injuries to heels and ankles **[19].** A method for muscle strengthening that is increasingly used in a variety of clinical situations is whole-body vibration (WBV) **[20, 21]**. The WBV is considered as a moving surface, so, the children needed to spend more time with both feet on the surface than when they walked over ground **[22]**. It is practiced while the user is standing in a static position or moving in dynamic movements **[23]**. Some studies have also found that WBV can increase BMD **[24]**. Techniques that involve proprioceptive, vestibular, and visual inputs are so beneficial to children with DS **[25]**. Therefore, the purpose of this study was to compare between the effects of rebounding exercise and WBV on functional capacity, genu recurvatum angles and BMD in children with DS.

2. Subjects, Materials and Methods

2.1. Subjects

Thirty children with DS from both sexes were enrolled in this study via National Institute for Neuro-Motor System. Their ages ranged from 6 to 8 years. They were able to understand the commands given to them. They were able to stand and walk independently. They had bilateral genu recurvatum angles ranged from 15 to 30 degrees as determined by plain x-ray measurement. The strength of quadriceps, hamstring and calf muscles is at least grade 3 according to Kendall et al. **[26]**. The Children who had one or more of the following criteria were excluded from the study: children with medical condition that would severely limit their participation in the study as vision or hearing loss, cardiac anomalies, pulmonary disorders, thyroid abnormality, history of previous surgical operation that interfered with the treatment or atlanto-axial instability or other musculoskeletal disorders. This work was carried out in accordance with the code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Parents of the children signed a consent form prior to participation as well as acceptance of the Ethical Committee of Cairo University was taken. All the procedures involved for evaluation and treatment, purpose of the study, potential risks and benefits were explained to all parents. The children were classified randomly into two groups of equal number: study group I received rebounding exercise and study group II received WBV. In addition, the two groups received the same designed exercise program.

2.2. Randomization

Forty three children were assessed for eligibility. Ten children were excluded as they did not meet the inclusion criteria and three children were excluded as their parents refused to participate in the study. Following the baseline measurements, randomization process was performed using closed envelopes. The investigators prepared 30 closed envelopes with each envelope containing a card labeled with either study group I or study group II. Finally, each child was asked to draw a closed envelope that contained whether he/she was allocated to the study group I or II. The study design is shown as a flow chart in Figure 1.

2.3. Methods

2.3.1. For evaluation

Preliminary evaluation:
Several demographic, anthropometric and physiological factors can influence the 6MWT in healthy individuals and in patients with chronic diseases. Shorter individuals and women present a shorter step length and, consequently, a shorter 6MWT. Obese individuals commonly present reduced lean body mass and, consequently, a shorter 6MWT **[12, 27]**. So, the weight and height were recorded using electronic weighing and measuring station. Neck x-ray was taken to exclude atlanto-axial instability. Functional capacity, genu recurvatum angles and BMD were evaluated by using 6MWT, plain X-ray of bilateral knee joints, Dual Energy X-ray Absorptiometry (DEXA) respectively***.*** The evaluation was done before and after 3 successive months of treatment.

2.3.1.1. Six Minute Walk Test

Six minute walk test is a sub-maximal test of aerobic capacity, in which the subjects walk as far as possible in 6 minutes (min.) around a pre-measured distance. It is a useful assessment tool for children with chronic conditions affecting the musculoskeletal system, because walking is a part of their everyday life **[28]**. Children were allowed to walk on an unobstructed, rectangular pathway following the guidelines of the American Thoracic Society. To ensure safety and to measure the exact distance walked in 6 min, the therapist followed closely with a stopwatch. The walking course distance of 20 meters (m) between turning points was used. Each child was instructed to cover as many laps of the course as possible in 6 min. without running **[29]**. A familiarity session occurred prior to the test session. On this session, the children practiced 6MWT. This session was particularly necessary for the children to ensure their comfort with the research team and protocol of evaluation.

2.3.1.2. Plain X-ray

Unilateral standing (weight bearing) X-ray film was taken. FUJIFILM Corporation Model, CR.IR 357 Fuji-computed RADIOGRAPHY, apparatus was used. The child stood holding on (rail, mother's hands, or assistant's hands). Then, the child was asked to flex one leg (untested leg) "unilaterally weight bearing". The film was taken from 90 degrees with a distance 90 cm from the child's knee. The same procedure was applied to the other knee. The tibiofemoral angle was measured. This angle results from intersection of two lines, the first is the anatomical axis of the femur, and the second is the anatomical axis of the tibia. The anatomical axis is the line lies longitudinally in the middle of the shaft of the long bones **[30]**.

2.3.1.3. Dual Energy X-ray Absorptiometry

Dual energy X-ray absorptiometry was used for the evaluation of BMD and monitoring of the effects of treatment on bone sites. It is most commonly used in children and adults. It is an efficient, precise and safe method that has a relatively low cost and widespread availability **[31]**. It consists of a central device with a padded platform and a mechanical arm (scanner) that is adjusted to emit low dose x-ray on the area required to be measured. The equipment is combined with a computer device with specific software to determine BMD. The DEXA was used for measuring BMD of the femoral neck, proximal tibia and distal tibia using bone mineral content in grams (g) by area of bone measured (cm^2) and expressed density as g/cm^2.

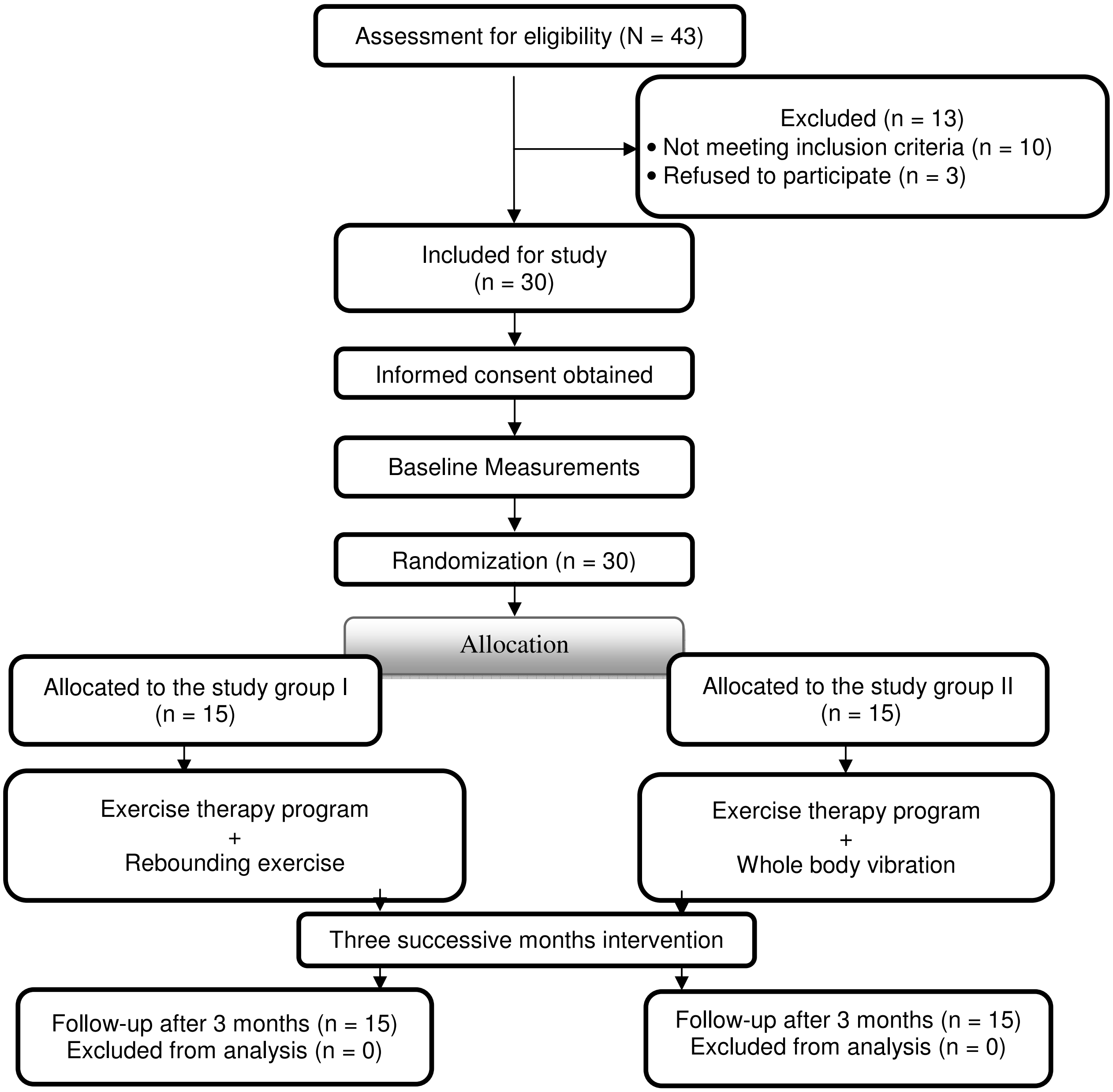

Figure 1: Flow chart showing the experimental design of the study

2.3.2. For treatment

The children in both groups received the same designed exercises program. This program focused on biomechanical correction to improve biomechanical faults, to alleviate tissue stress, to correct muscle imbalances, to improve weight bearing and functional capacity. It consisted of facilitation of muscle contraction acting on the knee joint, proprioceptive training, balance and postural control exercises and gait training. The total program lasted for 1 hour, 3 times/ week for 3 successive months. In addition, group I received rebounding exercise and the study received the WBV.

2.3.2.1. Rebounding exercise

Mini trampoline: 40 inches in diameter and about 12 inches high for a model with 6 legs, also have 40 inches long bar at the trampoline side which fixed with the trampoline by 3 longitudinal bars with 24 inches in height that gives the child something to hold onto if child is at risk for falling due to disturbance of the balance. The duration of treatment session was based on our pilot work and the work of others who recommended it for 15 minutes or more a day, though this can be broken in to multiple 3-5 minute groups **[32]**. Each rebounding session consisted of the following schedule: (3 min of rebounding) – (3 min rest) – (3 min of rebounding) – (3 min rest) – (3 min of rebounding). Thus, one treatment session corresponded to 9 min. of rebounding exercise. The bouncing started slowly as a warming up in short blocks for 5 min. as conducted by Witham et al. **[33]** in their study who mentioned that, the sessions included: a long warm up taking the child through sitting transitions (long sitting, side sitting and high kneeling); bouncing and/or being bounced without leaving the surface of the trampoline. Then, the child stood at the trampoline with his/her feet at the shoulder width and the therapist stood behind the child bouncing with him and guided the bounce. The child began to bounce up and down with maintaining a steady balance by holding on the hand bar. As the child could bounce alone, the therapist just controlled the bounce by asking the child to fast or slow the bounce (hand free manner) **[17]**. The therapist could control the bouncing by holding the child's legs or feet to increase the bouncing rate, gradually increased the bounce rate as the endurance increased

2.3.2.2. Whole body vibration

A commercially available WBV device (Vibraflex Home Edition II®, Orthometrix Inc, White Plains, NY) was used. It has a motorized board that produces side-to-side alternating vertical sinusoidal vibrations around a fulcrum in the mid-section of the plate. The frequency of the vibrations can be selected by the user. The peak-to-peak displacement, to which the feet are exposed, can be increased with increasing the distance of the feet from the center line of the vibrating board. Three positions are indicated on the vibrating board, marked as '1', '2' and '3', which correspond to peak to-peak displacements of 2 mm, 4 mm and 6 mm. The treatment schedule was adapted from published observational studies that had used the same WBV system as the present study to treat children with neuromuscular diseases and bone fragility disorders **[34, 35]**. Each WBV session consisted of the following schedule: (3 min of WBV) – (3 min rest) – (3 min of WBV) – (3 min rest) – (3 min of WBV) of WBV. Thus, one treatment session corresponded to 9 min. of exposure to WBV. The vibration settings used for each treatment session were documented as well as other clinical observations made during the vibration sessions. The session was terminated if the child complained of fatigue or pain. The child stood on the board with both feet touching the vibration plate. The feet were placed at an equal distance from the center of the board. The children wore shoes during the WBV sessions to have a more stable position on the vibration plate. The child was initially attached to the tilt table with two straps, one at the level of the pelvis and the other on the level of the knees. The initial tilt angle was set to 35 degrees. The goal for the subsequent sessions was to increase the angle of the tilt table and to eventually perform the WBV without a tilt table, using a WBV device placed on the ground. The speed of the progress toward this goal depended on the child's ability to maintain an upright posture under the conditions of WBV. The first treatment sessions were performed using a vibration frequency of 12 Hz, with the middle toe of each foot placed 5.5 cm from the neutral axis of the vibration plate (indicated as position '1' on the WBV device). The peak acceleration exerted by vibration increased with the frequency and the amplitude of the vibration. Therefore, higher frequency and higher amplitude are likely to elicit higher musculoskeletal force. The goal was to increase the vibration frequency to 18 Hz (in steps of 0.5 Hz every two treatment sessions). and the peak-to-peak displacement to 4 mm (as determined for the middle toe of each foot). The frequency was increased only if the child felt comfortable with the setting. Once the frequency of 18 Hz was reached, the feet were gradually placed wider apart until they were vertically below the hip joint. These target settings corresponded to a peak acceleration of approximately 2.6 g and were based on our previous experience from a small observational study which indicated that these settings are usually well tolerated by children with Down syndrome **[36]**. Thus, the middle toe of each foot was eventually placed between 8 cm and 11 cm from the neutral axis of the vibration plate, depending on the width of the child's pelvis. Whether using the tilt table or the ground-based WBV system, the children flexed their knees and hips between 10 and 45 degrees (to prevent the vibration from extending up to the head). Guided by the study physiotherapist, the children shifted their weight from side to side or increased and decreased the knee and hip angle. Other exercises included weight shift with rotation of the trunk, and alternate flexion and extension of knees.

Postural correction was encouraged through visual feedback (by performing the treatment in front of a mirror) and through the therapist's verbal cueing.

Statistical analysis

The collected data of the functional capacity, genu recurvatum angles and BMD of both groups were statistically analyzed to compare between the effects of rebounding exercise and whole body vibration. Descriptive statistics were done in the form of mean and standard deviation (SD) to all measuring variables in addition to the age, weight and height. Paired t-test was conducted for comparing pre and post treatment mean values in each group. Unpaired t-test was conducted to compare pre and post treatment mean values of all measuring variables between both groups. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through SPSS (Statistical Package for Social Sciences, version 20). The percentage of improvement was calculated according to:

$$\text{Percentage of improvement} = \frac{\text{post} - \text{pre}}{\text{pre}} \times 100$$

3. Results

3.1. Subjects' characteristics

Table 1, presented the mean± SD of age, weight and height of both study groups. There were no significant differences between both groups in the mean age, weight and height ($P > 0.05$).

Table 1. *Subjects' characteristics*

	Group I (n=15)	Group II (n=15)	*t*-value	*p*-value
Age (years)	7.11±0.56	7.52 ±0.63	1.88	0.07
Weight (Kg)	27.06± 3.79	27.86±4.43	0.53	0.59
Height (cm)	115.12± 4.59	117.33±6.85	1.04	0.32

Data are expressed as mean ± SD *kg: Kilogram* *cm: Centimeter* *P*-value: level of significance

3.2. Six- minute walk test

The raw data of the 6MWT for the two groups were statistically treated to determine the mean and standard deviation. Student-test was then applied to examine the significance of the treatment conducted for each group. The obtained results revealed no significant differences when comparing the pre-treatment mean values of the two groups ($P > 0.05$). Significant improvement was observed in both groups, when comparing their pre and post-treatment mean values ($P < 0.05$). While, no significant difference was observed when comparing the post-treatment results of both groups ($P > 0.05$). These are presented in table 2 and demonstrated in figure 2.

3.3. Genu recurvatum angle

It's presented in table (3) and demonstrated in figure 3 that, there were no significant differences when comparing the pre-treatment mean values of genu recurvatum angles for the two groups ($P > 0.05$). Significant improvement was observed in both groups, when comparing their pre and post-treatment mean values ($P < 0.05$). After treatment, significant difference was observed when comparing the post-treatment results of the two groups in favor of the group II ($P < 0.05$).

Table 2: Six minute walk test for both groups

	Group I (meter)	Group II (meter)
Pre	300 ± 9.26	294.67 ± 9.90
Post	350 ± 8.45	357.33 ± 13.74

% of improvement	16.67%	21.26%
***t*-test**	-36.23	-15.71
***p*-value**	<0.05*	<0.05*

Data are expressed as mean ± SD *P*-value: level of significance %: percentage
* Significant at $P < 0.05$

Table 3. Genu recurvatum angles for both groups

	Group I (n=15)		Group II (n=15)	
	Rt. Knee (degrees)	**Lt. knee (degrees)**	**Rt. Knee (degrees)**	**Lt. knee (degrees)**
Pre	20.33 ± 1.54	19.93 ± 1.49	19.73 ± 1.53	19.87 ± 1.41
Post	17.80 ± 1.70	17.60 ± 1.55	16.13 ± 1.89	15.07 ± 1.22
% of improvement	-12.5	-11.7	-18.3	-24.2
***t*-test**	5.82	18.52	15.32	11.86
***p*-value**	<0.05*	<0.05*	<0.05*	<0.05*

Data are expressed as mean ± SD *P*-value: level of significance %: percentage
* Significant at $P < 0.05$ Rt.: right Lt: left

3.4. Bone mineral density

The mean and standard deviation of both groups are presented in table 4 and demonstrated in figure 4. There were no significant differences when comparing the pre-treatment mean values of the two groups ($P > 0.05$). Significant improvement was observed in bone density of both groups. Significant differences were recorded when comparing their pre and post-treatment mean values ($P < 0.05$). Also, no significant differences were observed when comparing the post-treatment results of both groups ($P > 0.05$).

TTable 4. Bone mineral density measured for both groups

	Group I (n=15)			Group II (n=15)		
	Femoral neck (g/cm^2)	**Distal tabia (g/cm^2)**	**Proximal tabia (g/cm^2)**	**Femoral neck (g/cm^2)**	**Distal tabia (g/cm^2)**	**Proximal tabia (g/cm^2)**
Pre	0.58 ± 0.02	0.34 ± 0.09	0.56 ± 0.02	0.58 ± 0.02	0.34 ± 0.09	0.57 ± 0.01
Post	0.80 ± 0.04	0.48 ± 0.10	0.78 ± 0.05	0.83 ± 0.07	0.55 ± 0.08	0.83 ± 0.08
% of improvement	37.90	41.20	39.30	43.10	61.80	45.60
***t*-test**	-18.65	-4.17	-14.31	-19.36	-6.63	-13.46
***p*-value**	<0.05*	<0.05*	<0.05*	<0.05*	<0.05*	<0.05*

Data are expressed as mean ± SD g/cm2: gram/ centimeter square P-value: level of significance
%: percentage * Significant at $P < 0.05$

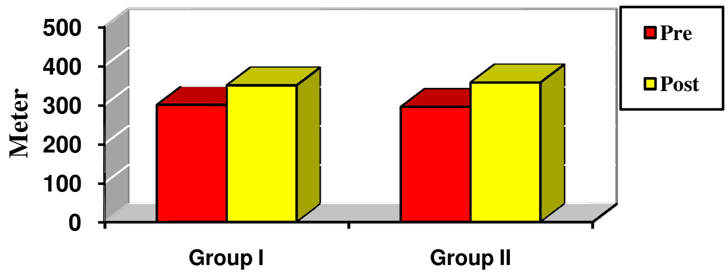

Figure 2. Pre and post treatment mean values six minute walk test for both groups

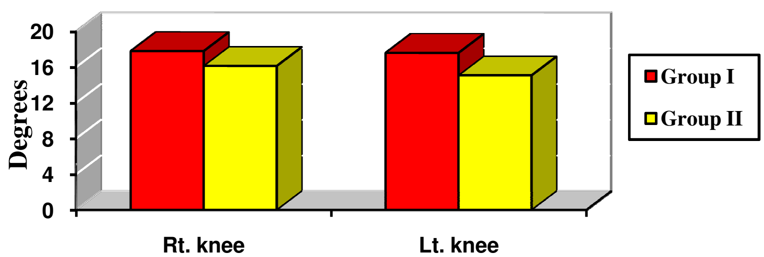

Figure 3. Post-treatment mean values of genu recurvatum angle for both groups

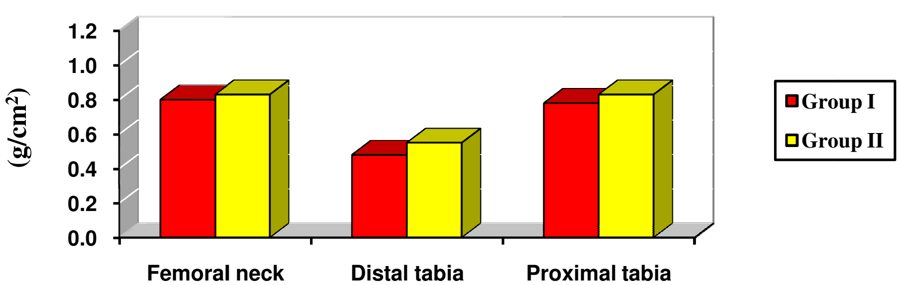

Figure 4. Post-treatment mean values of bone mineral for both groups

5. Discussion

The present study was essentially planned aiming to compare between the effects of rebounding exercise and whole body vibration on functional capacity, genu recurvatum angle and BMD in children with DS.

Comparing between the mean values of pre-treatment results of 6MWT, genu recurvatum angles and BMD revealed no significant differences between both groups but showed bilateral pathological genu recurvatum, decreasing of 6 MWT and BMD in comparison to the normal values of the children in the same age group **[4, 37, 10]**. These results may be clarified by the words of Martin et al. **[2]** that attributed them to musculoskeletal and neuromuscular system impairments found in children with central hypotonia. These impairments include motor skills delay, hypermobile or hyperflexible joints, decreased strength, decreased activity tolerance, poor attention and motivation, and poor reflexes. Peredo and Hannibal **[38]** added that, the complex feedback loops of sensory processing and motor output are implicated. There are often sensory processing deficits (vestibular, proprioceptive, visual, and tactile) that are not alerting the brain of changes in body position.

Genu recurvatum is a consequence of poor control over the knee joint due to muscle weakness, impaired tonus, and deficit in joint proprioception **[39]**. Decreased step length, stride length, velocity, and cadence are primary functional gait deviations associated with this deformity. Increased lateral trunk displacement and increased energy costs also are likely to be noted **[40]**.

After the suggested period of treatment, significant improvement in the mean values of all measuring variables was recorded in both groups. This improvement could be attributed to the combined effect of a designed exercise program and sensory stimulation through rebounding exercise or WBV. They worked at a multi-system level, the visual, proprioceptive, and vestibular inputs leading to modulation of muscle tone which encouraged the appearance of normal motor response, enhanced the relationship between the sensory and motor system, and improved the sensorimotor integrative process. This is confirmed by Root **[41]** who stated that, normalization of muscle tone and evocation of desired muscular response accomplished through usage of appropriate sensory stimuli. Rine **[42]** reported that, stimulation of otolithic organs by transient linear acceleration and/or by changes in head position with respect to gravity evokes phasic and tonic vestibule–ocular and vestibule–spinal reflexes, which act on the head and limbs to maintain posture. Smith and Cook **[43]** added that, the rebounding has been observed to decrease hypotonia with the correct application, as vigorous bouncing increases tone by stimulating the sensory systems.

The functional weight-bearing exercise programs provide an improved and more consistent proprioceptive feed-back that in turns improves the control of movement. These exercises have been shown to have an improving effect on balance, gait, and lower-limb strength among children with DS with moderate or no cognitive impairments **[44]**. In addition, the weight-bearing exercises allow for reactivation of the proprioceptors **[45]**. Proprioceptive input to central nervous system is very important for conscious awareness of joint position sense and motion so clinicians need to evaluate kinesthetic deficits and to design exercise programs to improve kinesthetic awareness **[4]**. Exercise has important osteogenic effect, mainly when high-impact and weight bearing PA occur. At the same time, the mechanostat theory suggests that both systematic exercise and PA could drive to a direct osteogenic effect on bone mass and an indirect osteogenic effect by increasing muscle size and strength and hence the tensions generated on bones **[46]**.

Comparing of the pre and post-treatment results of the 6MWT of both groups, it was observed that functional ability level of children in both groups was improved. These results were consistent with the findings of the American Thoracic Society which emphasized that several factors may be contributed to functional improvement as increased stride length because of improved ROM; improved muscular endurance; improved cardiopulmonary efficiency, improved circulation and improved biomechanical loading on the joints resulting in a more comfortable and efficient gait. Behavioral and psychological factors such as increased confidence, improved body image, and decreased fear of movement or injury could also result in improvement in functional walking **[47]**.

As the control centers in the brain use the signals to develop a subjective awareness of the knee position in relation to the environment and relating these experiences to those of other sensory systems during standing. The connection with reticular formation induces increased alertness and awareness and so these interactions of various systems lead to orientation of the child in space. This comes in agreement with the study of Walker **[48]** who reported that, rebounding stimulate neural activity, engage every brain and body cell. Disabled children exhibiting a poor sense of rhythm, coordination, and balance have been shown to benefit through improving the mind/body connection.

Rebound exercise can combine two important aspects: strengthening and aerobic oxygen **[49]**. It's exhilarating to jump up and experience weightlessness for a split second and then come down with an extra gravitational force (G-force). Anytime you jump higher you increase the G-force. The bottom line is that strength training helps provide the cells with the essentials of life: oxygen and nutrients **[50]**. Jumping activity which added to the program of treatment in this work for the children with DS effectively evoked the automatic and dynamic postural control. Moreover, the standing performances might be improved due to the transferred effects via the practice of dynamic jumping activity as reported by Wang and Chang **[51]**. Adding to that, the willing of the child to participate in the rebounding exercise, with great happiness and confidence, which considered as an attractable and enjoyable playing therapy **[52]**.

Recent work has suggested that low amplitude, low frequency mechanical stimulation of the human body is a safe and effective way to exercise musculoskeletal structures. In fact, increases in muscular strength and power in humans exercising with specially designed exercise equipment have been reported **[53, 54, 55]**. Whole body vibration has been recently proposed as an exercise intervention because of its potential for increasing force generating capacity in the lower limbs. Its recent popularity is due to the combined effects on the neuromuscular and neuroendocrine systems. Preliminary results seem to recommend vibration exercise as a therapeutic approach for sarcopenia and possibly osteoporosis **[56]**. Torvinen et al. **[57]** showed a net improvement of 8.5% in vertical jumping ability after four months of WBVT performed with static and dynamic squatting exercises with small vibration amplitudes (2 mm) and frequencies ranging from 25 to 40 Hz in sedentary subjects.

Three studies focused on children and adolescents with low BMD **[58]**. One study included male and female children with osteogenesis imperfecta, a disease characterized by brittle bones **[35]**. One study included female children with endocrine disorders that had low BMD and were not taking any medication that could affect their bones **[59]**. The third study included white female adolescents with low BMD who had previously sustained a fracture. Participants in this study had no underlying diseases or chronic illnesses, were not taking any medications, and had completed puberty **[60]**.

Non significant differences were recorded between both groups regarding to BMD and 6MWT when comparing the post treatment results of the two groups. While, significant difference was recorded in genu recurvatum angle in favor of the study group II. This is supported by Delecluse et al. **[61]** and Roelants et al. **[54]** who highlighted the possibility that long term programmes of WBVT may produce significant improvements in muscle function of the leg extensors in untrained subjects.

As more supportive evidence, a recent study showed that WBV therapy was superior to a low intensity resistance training programme in improving isometric and dynamic muscle strength in middle aged and older women **[55]**. A mini-trampoline is similar to the effects of a full body vibrator except for the WBV works at a much faster speed. The vibrator can give faster results in terms of the tone. It’s like getting thousands of bounces a minute. It’s much easier on the joints and the subject can control the speeds **[62]**. A rebounder also takes a lot more effort and time. Simply standing on a WBV platform, the machine does all the work while the body gets all the benefits. 100% of all the muscles in the body are activated and exercised at the same time, as well as all the systems in the body being stimulated, even including the brain and eyes. A rebounder produces these muscle contractions every time you bounce, but the low-impact, oscillating platform of a WBV produces the same reaction up to 30 times per second **[63]**.

6. Conclusion

From the obtained results of the current study, it can be concluded that the rebounding exercise and whole body vibration are effective additional tools to the rehabilitation program with genu recurvatum, low mineral density and decreased functional capacity for children with Down syndrome. But the whole body vibrastion is more effective than whole body vibration regarding to correction of genu recurvatum angle.

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