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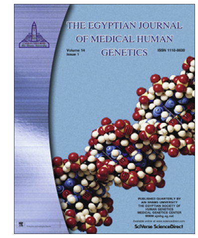

ORIGINAL ARTICLE

Effect of partial weight bearing program on functional ability and quadriceps muscle performance in hemophilic knee arthritis

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Quadriceps training exercise program

Abstract Recurrent joint bleeding in persons with hemophilia is known to lead to joint damage associated with pain, loss of range of motion and function. The researcher was motivated by the essence of the importance of partial weight bearing program in rehabilitation of lower limb conditions and the lack of literatures regarding these exercises in rehabilitation of hemophilic knee arthritis. The purpose of this study was to investigate the effect of partial weight bearing program on functional ability and quadriceps muscle strength in children with hemophilic knee arthritis. Thirty patients had participated in this study; with age ranged from eight to twelve years. They were randomly assigned into two equal groups. Patients were evaluated pre and post treatment for their functional walking, and isometric strength of quadriceps. The control group (group A) received quadriceps training exercise program, while the study group (group B) received a program of partial weight bearing added to the same exercise program of group A. Treatment was given 3 times/week, every other day, for six consecutive weeks. The results of the study revealed that both groups demonstrated a significant increase in function, as measured by the six minute walking test (6MWT), although there was no significant difference between both groups concerning improvement of function. Quadriceps isometric muscle strength was significantly improved in both groups, in favor of group B (study group). To conclude the partial weight bearing program may be used as a therapeutic intervention for improving functional ability, and muscle performance in children with hemophilic knee arthritis.

1. Introduction

Hemophilia is a congenital disorder resulting from a deficiency of clotting factors. Affected individuals lack factor VIII or IX procoagulant activity and consequently experience repeated, often spontaneous, hemorrhagic episodes in organs, including the locomotor tract, muscles, and may gradually encounter serious problems in their activities of daily living [1].

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Hemophilia, is the most common inherited severe bleeding disorder, it is an X-linked disorder that affects males of all ethnic groups [2].

Any joint that has three or more bleeding episodes over a period of 3–6 months is a target joint and is much more susceptible to subsequent bleeding and arthritic changes [3,4]. The knee joint is the most frequent site of serious bleeding in patients with hemophilia. Knee is the largest weight-bearing joint of the body that is subjected to tremendous stresses and strains during everyday life [5]. Despite aggressive regimens of factor replacement therapy, bleeding occurs leading to arthropathy and structural damage of joints, and causes muscle atrophy resulting from lack of activity [6–8]. Muscle weakness reduces bone loading, leading to demineralization and osteoporosis [9]. Joint tissue destruction resulting from hemophilia is similar to that seen in rheumatoid arthritis. This destruction results in invasive hypervascular synovial hypertrophy, chronic synovitis, articular cartilage damage, bony hypertrophy, and subchondral cysts [3,4,10]. Joint damage is associated with pain, loss of range of motion and function and long term physical and psychosocial impairments [11,12].

The fact that muscular strength is decreased in hemophiliacs has been demonstrated by different authors, who have measured muscular strength in hemophiliacs compared with control subjects [13,14]. Regular exercising (30 min at least three times per week) may decrease or prevent the progression of hemophilic arthropathy [15,16]. Regular participation in physical activity is an important component of the management of hemophilia [17]. Episodes of bleeding, periods of decreased activity predispose this population to impaired strength [14]. Individuals with hemophilia who exercise regularly, however, exhibit fewer bleeds [18] and have strength and daily functional abilities matching their peers who do not have hemophilia [19]. The purpose of exercise is to maintain and increase joint range of motion, maintain and increase muscle strength, and improve proprioception and co-ordination [20].

In the past, patients with hemophilia tended to be overprotected by their parents, and often are afraid to exercise or participate in physical education in school. However, therapy with regular coagulation factor replacement now allows these patients to undertake physical activities without a high risk of bleeding episodes [21]. Family members should be actively involved in the management of bleeds so that they can help the hemophilic patient with rehabilitation and exercise programs. In particular, parents and siblings can offer stimulation and encouragement to the patient to carry out simple, regular exercises, such as using a towel to resist hip abductors. Achieving adequate education for both patients and their family members is very important [22]. The required exercises should be carefully demonstrated, and the demonstrations should be supported by written instructions provided to the family in the local language [20]. Hemophilic children have lower muscle strength than their peers. The results of Pietri et al. [23] showed that children with unilateral hemarthrosis of the knee have a decreased muscle function. These results led to the recommendation for early initiation of strength training. A sufficient muscular strength is necessary not only for range of movement, but also for the control of the joint and the absorption of energy.

Training on a Swiss ball is an appropriate way to be used in partial weight bearing positions, as the Swiss ball promotes strengthening that mimics various daily activities [25].This study will be conducted to study the effect of partial weight bearing program on treatment of hemophilic arthritis.

2. Patients, instrumentation and procedures

2.1. Patients

This study was conducted in the El Chabrawishi Hospital, Cairo, Egypt. The study was applied in the Department of Physical Therapy on 30 male patients whose ages ranged from 8 to 12 years and were randomly assigned into two groups.

2.1.1. Control group (group A)

Consisted of fifteen patients who received a program of quadriceps exercises in the form of static quadriceps muscle contractions (quadriceps muscle setting) with the knee in full extension, straight-leg raises with the patient supine, short arc movements from 10° of knee flexion to terminal extension, for six weeks.

2.1.2. Study group (group B)

Consisted of fifteen patients who received a program of partial weight bearing in the form of supine wall push, wall push against Swiss ball, supine half bridging exercises for six weeks. Partial weight bearing program was added to the same quadriceps exercises as in the control group.

In both groups, each exercise was repeated 3 sets of 10 repetitions. The patients rested 1 min after the conclusion of each set [26]. Repetitions began with 10 repetitions for each exercise and progressed by two repetitions each week [27].

Inclusion criteria:

1. Patient diagnosed as having moderate hemophilia,
2. Age of patients ranged from 8 to 12 years,
3. Approvals by their hematologists were obtained to participate in the exercise program.

Exclusion criteria:

1. The inability to attend exercise sessions at least twice a week for six consecutive weeks,
2. Surgical procedures performed six weeks prior to treatment or during the exercise program,

Figure 1 Lafayette Manual Muscle Test System *(Model 01163, Lafayette Instrument Company, Lafayette, IN, USA)*.

3. A major bleeding episode that poses a risk or prevents exercising,
4. Presence of fixed contracture in the target joint or usage of orthotic devices.

2.2. Instrumentations

2.2.1. For evaluation

2.2.1.1. Lafayette Manual Muscle Test System. The Lafayette Manual Muscle Test System (Model 01163) (Fig. 1) features a lightweight (10.6 oz) microprocessor-control unit that measures peak force (pounds or kilograms), time to reach peak force, and total test time, while storing up to 52 tests. Test times can range from 1–10 s, and an audible tone indicates the end of the preset time. The unit provides a built-in calibration routine that verifies a valid calibration [29].

2.2.2. For treatment

2.2.2.1. Swiss ball. To provide resistance during the partial weight bearing of group B.

2.3. Procedures

2.3.1. For evaluation

All patients were assessed before and after the exercise program for their functional walking using the 6-min walking test, and strength of the quadriceps muscle using the Lafayette Manual Muscle Test System. Patients received verbal descriptions of all procedures.

2.3.1.1. Functional walking. The Six Minute Walking Test (6MWT) is used to measure walking ability and baseline cardiovascular function of people with disease or low levels of fitness [30]. Participants walked in 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 physical therapist followed closely with a stopwatch. The 6MWT is a submaximal, quantitative evaluation of functional exercise capacity and is reflective of the ability to perform daily physical activities. The short-term reproducibility of 6MWT is excellent.

The object of this test is to walk as far as possible for 6 min. The patient will walk back and forth in the hallway. The walking course must be 30 m in length. A 100 feet hallway is, therefore, required. The length of the corridor should be marked every 3 m. The turnaround points should be marked with a cone (such as an orange traffic cone). A starting line, which marks the beginning and end of each 60-m lap, should be marked on the floor using a brightly colored tape [31]. The walking course was modified according to the space available in the department. A 10 m hallway distance was used and a marker was placed every 3.3 m, and a cone was put at the end of the 10 m pathway to allow for the turnaround points, for a total of 6-min walking distance. A stopwatch was used to calculate the walking distance.

2.3.1.2. Testing strength of quadriceps muscle. The testing procedure was performed using the Lafayette Manual Muscle Test System [29]. A maximal isometric knee extension test was performed at a knee angle of 25° of flexion. This angle was selected to correspond with the knee angle at which the force production is of crucial importance in walking, as has been shown in biomechanical analyses of this activity. Patients were positioned upright without back support, with the hips in approximately 90° of flexion. The patient stabilized the trunk by grasping the table; the thigh was stabilized by the therapist's hand. The test was performed as a "make" test, in which the patient exerted force against the dynamometer, which was held stationary by the therapist, with a build-up phase of 2 s, and steady maximal force exertion over 3 s. Three test trials were performed and the mean force in kilogram (kg) was calculated.

2.3.2. For treatment

1. Quadriceps training will include

- Static quadriceps exercises. Static quadriceps contraction will be performed five times initially, building up to 10 repetitions as tolerated, two to three times per day [32].
- Straight-leg raise exercise. The non-affected leg will be flexed for 90° at the knee joint; the affected lower limb is straight on the table. The patient will be asked to raise the affected lower limb straight to the level of the other leg [33].
- Short arch quadriceps exercise. The affected lower limb will be straight on the table with a pillow placed under the affected knee. The patient will be asked to press on the pillow and straighten the knee and hold for 6 s, then relax and return to the starting position [33].

2. Partial weight bearing program will include

- Supine wall push exercise. The start position is supine with the affected leg against wall, the other limb straight. The patient pushes against wall for 30 s.
- Wall push against Swiss ball exercise. The start position is supine with a Swiss ball between patient's legs and the wall. The patient pushes against the ball for 30 s.
- Supine half bridging exercise. The start position is lying on back, knees bent. The patient tries to keep the spine neutral and hinging up from the hips, moves into a bridge.

3. Data analysis

The raw data were analyzed to determine the mean ± standard deviation for the measured variables of the two groups before and after treatment. Paired t test was used to show the difference between before and after treatment in each group as regards the functional walking variable and the strength training variable. Unpaired t test was used to show the difference between the two groups as regards the functional walking variable and the strength training variable before and after treatment with the level of significance at $P < 0.05$.

4. Results

The age of group A ranged from 8 to 12 years with a mean of 9.93 ± 1.39 years. The age of group B ranged from 8 to 12 years with a mean of 10.2 ± 1.37 years. There was a statistically significant difference as regards the functional walking

Table 1 Functional walking variable of both groups A and B before and after the exercise program.

Functional walking	Before program	After program	*T*-value	*P*-value
Group A	37.067 ± 12.57	69.067 ± 8.811	6.99	< 0.0001*
Group B	34.267 ± 8.876	68.867 ± 7.633	10.198	< 0.0001*

* Significant.

Table 2 Functional walking variable between group (A) and group (B) before and after the exercise programs.

Functional walking	Group (A)	Group (B)	*T*-value	*P*-value
Before program	37.067 ± 12.57	34.267 ± 8.876	0.7047	0.49**
After program	69.067 ± 8.811	68.867 ± 7.633	0.066	0.948**

** Non-significant.

Table 3 Strength training variable of group A and B before and after exercise program.

Strength training	Before program	After program	*T*-value	*P*-value
Group A	9.967 ± 3.801	21.2 ± 5.87	15.086	< 0.001*
Group B	9.967 ± 5.118	27.567 ± 8.579	10.859	< 0.001*

* Significant.

Table 4 Strength training variable between group A and group B before and after the exercise program.

Strength training	Group (A)	Group (B)	*T*-value	*P*-value
Before program	9.967 ± 3.801	9.967 ± 5.118	0.000	< 0.001**
After program	21.2 ± 5.87	27.567 ± 8.579	2.37	0.025*

* Significant.
** Non-significant.

mean values of both groups A and B before and after treatment ($p < 0.001$), Table 1.

There was a non-statistically significant difference between both groups, as regards the functional walking mean values before and after treatment, ($p < 0.001$), Table 2.

There was a statistically significant difference as regards the strength training mean values of both groups A and B before and after treatment ($p < 0.001$), Table 3.

There was a non-statistically significant difference between both groups, as regards the strength training mean values before treatment, while there was a statistically significant difference between groups after treatment ($p < 0.001$), Table 4.

5. Discussion

Children with hemophilia generally have decreased strength (force-generating capacity) and flexibility, and are less active, having lower aerobic working capacity than their unaffected peers [15,26,35,36].

This is a randomized clinical study which was conducted to investigate the effect of partial weight bearing program on treatment of children with hemophilic knee arthritis. The rationale for this study was to introduce a new intervention (partial weight bearing program) in the rehabilitation of patients with moderate bleeding disorders.

The results of the present study revealed that both groups (those who received a program of quadriceps exercise and those who received a program of partial weight bearing in addition to the same quadriceps exercises) demonstrated a significant increase in function, as measured by the 6MWT, although neither of the exercise groups superimposed on the other. This means that both the exercise programs were not different in their implication on function.

Several factors may have contributed to functional improvement: increased stride length due to improved ROM; improved muscular endurance; improved cardiopulmonary efficiency; improved circulation; and improved biomechanical loading on the joints due to gains in ROM and muscle strength, all these factors result in a more comfortable and efficient gait. The improvement in functional walking also could result from behavioral and psychological factors such as increased confidence, improved body image, and decreased fear of movement or injury [31].

The strength of quadriceps muscle was significantly improved in both groups, in favor of group B by 6.367 kg as measured by the Lafayette Manual Muscle Test System. This group received the partial weight bearing program added to quadriceps training.

These findings are in accordance with those of Hilberg et al. [24] who tested proprioceptive performance and isometric muscle strength in 9 participants with hemophilia who took part in a 6-month specialized training program, and showed improvement of both variables. Comparing our study to those of Hilberg et al. we find similarities in strength gain. Our participants were prescribed an exercise program based on their joint integrity, pain, bleeding history, strength, and available ROM. Participants were allowed to progressively increase the intensity of exercise up to 75% of the preprogram strength measures. The clinical relevance of this finding indicates a more intensive strengthening program can be both safe and effective.

In another study Mulvany et al. used a specialized training program which included gentle strength training with low resistance, performed for 20–25 repetitions. This low-intensity, high repetition program was performed to apply minimal stress to the joints. In this study the hemophilic elbow joints showed an improvement of elbow muscles' flexion strength. The participants also showed a significant improvement in maximal isometric leg muscle strength, as measured by leg press [31].

Apparently, in the current study muscle strength was more improved by adding a partial weight bearing program to the quadriceps training. We therefore do not advocate replacing the traditional quadriceps training exercises by partial weight bearing exercises, but rather suggest a combined use of these programs to gain more improvement of quadriceps muscle strength.

6. Conclusion

The more significant improvement in quadriceps muscle strength, gained by adding partial weight bearing program to the quadriceps exercises program, is of great interest, as it shows the importance of using partial weight bearing in treatment of hemophilic knee arthritis.

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