Original Article

EFFECT OF TREADMILL TRAINING ON QUADRICEPS AND HAMSTRING MUSCLES STRENGTH IN CHILDREN WITH KNEE HEAMARTHROSIS

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ABSTRACT

Background: Heamarthrosis is the most disabling complication of hemophilia causing pain, swelling, limited joint range, and weakness. Without appropriate treatment, chronic heamarthrosis remains a serious problem with permanent disability. The Purpose of this work was to study the effect of treadmill training on quadriceps and hamstring muscles strength in children with knee heamarthrosis.

Material and methods: Thirty hemophilic male children with unilateral knee heamarthrosis, their ages ranged from 8 to 12 years. They were divided randomly into two groups in equal numbers, control (A) and study (B), 15 patients each. Both groups received traditional treatment program for one hour 5 days / weak, in addition the study group received treadmill training for 30 minutes. Peak torque of quadriceps and hamstring muscles was measured by Biodex Isokinetic Dynamometer. Knee swelling was measured by tape measurement. Assessment was performed before and after three successive months of treatment.

Results: The results revealed significant difference in all tested variables ($p<0.05$) after three months of treatment in both groups in favor to the study group.

Conclusion: Treadmill training is beneficial in increasing muscle strength and reducing joint swelling in children with knee heamarthrosis.

KEYWORDS: Treadmill, Isokinetic, Peak Torque, Knee Heamarthrosis.

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INTRODUCTION

Hemophilia is a sex linked, autosomal recessive, X chromosome disorder with frequent bleeding episodes. Because of lack of or dysfunction of plasma coagulation factors (F VIII deficiency in hemophilia A and F IX deficiency in hemophilia B, or Christmas disease), once bleeding starts it cannot be stopped [1]. Bleeding may be either life threatening (cerebral) or musculoskeletal [2, 3].The hall mark sign of hemophilia is bleeding and most of the bleeds happen in either muscles or joints as well as soft tissues. Long term disabling complications are common after bleeds [3, 4, 5]. Severity of hemophilia depends on the plasma level of clotting factor (1 international unite =1%). Hemophilia is classified in to severe (<1%), moderate (1-5%) or mild (>5-<40%).In severe types spontaneous bleeding with apparent trauma is a diagnostic sign, while moderate hemophilia bleeding is caused by trauma or surgery. In mild cases bleeding is uncommon and requires a major trauma or surgery. [6, 7, 8]

Repeated joint bleeds lead to pain, deformity and cause permanent disability. This is known as

hemophilic arthropathy[9]. Bleeding in joints represent 70% to 80% of the bleeding episodes with knee joint being the mostly affected joint (45%). Hemophilic arthropathy results in loss of muscle mass which could be attributed to long-term immobilization due to repeated bleeding episodes and because of reduced physical activity.[10]

As a consequence of the bleeding episodes, immobilization and decreased physical activities hemophilic patients face serious problems as loss of muscle mass, decreased strength, balance problems and proprioception loss.[11]

The physical condition, muscular strength, aerobic and anaerobic resistance and proprioception are all diminished in hemophiliacs[12]. Peak torque values of knee flexors and extensors in hemophilic children age ranged from 7 to 12 years with unilateral involvement showed significant decrease in the involved knee. Muscle atrophy and muscle weakness can be attributed to the effect of immobilization which is usually found around the affected joint [13].

Biodex System (Biodex Medical Systems, Inc, Shirley, New York) allows concentric and eccentric contractions, modes for passive range of motion, isometric, and isotonic measurement of strength (torque output) throughout range of motion in hips , knees, ankles and trunk muscles and provides protections from impact during accelerations/decelerations.[14]

Hemophiliacs can exercise safely, although they should avoid contact sports. Regular exercises help prevent joint problems through improving muscle strength and also reduce possible joint problems after repeated bleeding in target joints.[15]

Early rehabilitation is important in order to control the consequences of the bleeds. Rehabilitation should focus on improving walking abilities [16]. One of the most effective and available tool to achieve this goal is treadmill. It is safe as the speed and walking distance can be adapted according to patient abilities.[17]

MATERIALS AND METHODS

Study Design: This study was a randomized controlled trial, performed over the period from December 2013 to April 2014 at the outpatient clinic faculty of physical therapy, Cairo University, Egypt.

Subjects: Thirty hemophilic male children (moderate type A and B) with unilateral knee hemarthrosis, their ages ranged from 8 to 12 years participated in this study. They were selected from the outpatient clinic, Faculty of Physical Therapy, Cairo University and Abo- Elreesh Hospital, Cairo University. They were divided randomly into two groups of equal numbers, control (group A) and study (group B), 15 patients for each. They suffered from unilateral knee hemarthrosis. The joint problems (pain and bleeding) ranges from mild to moderate according to the classification of hemophilia recommended by the Orthopedic Advisory Committee of the World Federation of hemophilia [18]. They were able to walk independently. All children were clinically and medically stable. They were not suffering from acute joint and muscle bleeds during treatment time and they received the same medical treatment to control bleeding. Children with advanced radiographic changes including (Bone destruction, Bony ankylosis, Knee joint subluxation or Epiphyseal fracture) or congenital or acquired skeletal deformities in both lower limbs were excluded. Both groups received exercise therapy program including (ultrasound, stretching and strengthening exercises) for one hour 5 days/week, while the study group; received a designed exercise program in the form of treadmill training for 15 minutes.

Instrumentations: A universal weight and height scale was used to determine the children's weight and height. Tape measurement was used to measure circumference of the knee joint in centimeters at mid patella. The Biodex Isokinetic Dynamometer was used for assessment of isokinetic muscular performance of the quadriceps and hamstring muscles of all children. It is one of the most comprehensive computers driven, biomechanical musculoskeletal assessment and rehabilitation with 3 pro multi-joint systems (Biodex medical system, Shirley, New York, USA). It is available at the Faculty of Physical Therapy, Cairo University. The subjects were tested to measure performance parameters of quadriceps and hamstring muscles during the concentric contraction mode. The system is pro-

vided with a computer (DELL) compatible device that collects, displays, stores the data and controls the movements of the dynamometer. The dynamometer uses a direct current servo-motor (1/2 horsepower) offering isokinetic, isometric, eccentric and passive modes for all joints of the body. The system is equipped with a specific testing and rehabilitation chair with a special reclined sitting surface seat. The machine is provided with many attachments and isolation straps to secure the trunk, shoulder, knee and ankle joints. It is provided with computer software with preset menu of programs. All information is entered through a typewriter style keyboard into its processor. It provides the final results in the form of testing data chart, graph recordings of torque, speed, time, motion, work, power and different ratios and printed results. Torque values were automatically adjusted for gravity by the Biodex Advantage Software v.3.2. Calibration of the Biodex dynamometer was performed according to the specifications outlined in the manufacturer's service manual. The trial-to-trial and day-to-day reliability and validity of torque measurement of the Biodex System were all previously established. Ultrasound unit used in this study was ultra combi 707. The device is a microprocessor controlled unit for continuous and pulsed US therapy. It permits adjustment of intensity between 0 and 2 w /cm^2 with a frequency of 1 MHz and 3 MHz. The US device consists of mode selector (continuous or pulsed), automatic timer control, and having an ultrasound head with a diameter of 5 cm and an indicator lamp which is off when there is contact of more than 50%, between the head and treated area, when this contact is less than 50%, the indicator lamb is on .Motorized treadmill 770 (E.220V, 50HZ, and 2.2 Kilowatts) was used as a designed program for the study group. This model allows the child to exercise in a safe environment with adequate space, and with controlling of all important parameters aiming for motor rehabilitation.

Procedure: Evaluation of each child was conducted before starting and after termination of the treatment (after 3 successive months). Assessment of knee effusion was performed from supine lying position with the knee in a comfortable position, round measurements using a tape was used to determine knee joints circumferences at the level of the mid-patella[19]. Isokinetic pre-test and post test measurements of concentric hamstrings and quadriceps muscles were performed for every child at two different velocities (60 and 120 deg/sec) using Biodex Isokinetic Dynamometer. Before starting testing protocol warming up exercises for 5 minutes were performed. Biodex system 3 Dynamometer (Biodex Medical System, Shirley, N Y) was conducted to measure the peak torque of knee flexors and extensors of the affected limb. It is available at the Faculty of Physical Therapy, Cairo University. A comfortable setting position was guaranteed for every child with his body was stabilized by straps over chest, waist and the thigh. The range of motion was set at 0 to 90 degrees of knee flexion. Familiarization was conducted before the testing protocol using 5 repetitions at 120 deg /sec. The testing protocol order was form slow to fast speed: 60 and 120 deg/sec. Only verbal instructions were used to encourage the child to perform 5 repetitions at each speed. Peak torque for knee flexors and extensors at 60 and 120 deg /sec were done. Rest between speeds for 2 minutes was given for every child.

The control group received a designed exercise program for one hour, it was conducted 5 days/ week for 3 successive months in the form of therapeutic ultrasonic, strengthening exercises and stretching exercises.

Therapeutic ultrasonic: The subject was relaxed in comfortable supine lying position, The skin of the treated area (knee joint) was cleaned, then pulsed ultrasound waves of 1 MHZ frequency and 1.5 W/cm^2 was applied for 10 minutes.[20]

Stretching exercises: were conducted to maintain length and elastic recoil of all soft tissue liable to be tight especially the Achilles tendon, hamstring, hip flexors and adductors of lower limbs and wrists, fingers flexors and elbows flexors. According to Carolyn and Lynn, 2007 [21]: The extremity was moved slowly through the free range to the point of restriction. Padding was used in areas where there is minimal subcutaneous tissue or bony prominence. Firm and comfortable grasp was applied proximal to the joint to firmly stabilize the proximal segment and distal to the joint to move the distal segme-

nt. Very gentle traction force was applied to the moving joint in order to avoid joint damage during stretching procedure. The stretching force was applied in a gentle, slow, and sustained manner by taking the joint to the point of tightness and then moved just beyond without inducing pain. Stretching was applied for 30 seconds followed 30 seconds rest and repeated 5 times/day and 3 sessions/week. This time for rest between sessions allows tissue healing and minimizes post exercise soreness.

Strengthening exercises: Static muscle contraction for quadriceps, hamstrings, dorsiflexors and planter flexors for 15 min. Each child was instructed performed five times initially, building up to 10 repetitions as tolerated, two to three times per day.[22]

The study group received the same physical therapy program for the control group in addition to the treadmill training exercises. They were instructed to walk on the treadmill with a speed of 1.5 kilometers/hour and 0 degree of inclination for 5 minutes as a warming up. Then, the speed was increased gradually to reach 3 kilometers/hour and 10 degrees inclination for 20 minutes. At the beginning the child was allowed to hold the hand rails by two hands and gradually leave one hand and finally without support. The child was instructed to look forward and don't look downward on his feet during walking as this may cause falling. The speed was returned to 1.5 kilometers/hour and 0 degree of inclination for another 5 minutes as a cooling down 23. Finally, Walking was stopped immediately when the child felt pain, fainting, or shortness of breath.

RESULTS AND TABLES

The raw data of isokinetic measurements (peak torque at knee flexors and extensors at 60 and 120 deg/sec) and knee circumference (at mid patella of the affected knee) were statistically treated to determine the mean and standard deviation of the measuring variable, for the two groups before and after three months of treatment. Then t-test was applied to examine the significance of treatment procedures conducted in each group. No significant difference was observed when comparing the pre-treatment mean values of the two groups. Significant improvement was observed in the measuring variable of the control group and the study group, when comparing their pre and post-treatment mean values. Table (1) demonstrates the physical characteristics of patients in both groups (A&B).

Table 1: characteristics of the participants of both groups.

Items	Group A		Group B		Comparison		
	Mean	±SD	Mean	±SD	t-value	P-value	S
Age (yrs)	10.06	±1.53	10.26	±1.38	0.37	0.71	NS
Weight (Kg)	31.4	±1.91	31.66	±2.43	0.33	0.74	NS
Height (cm)	122.26	±4.16	124.06	±3.47	1.28	0.2	NS

SD: standard deviation, P: probability, S: significance, NS: non-significant.

Fig 1: pre and post treatment mean values of peak torque of the knee flexors at (60 deg/sec) for both groups (A and B).

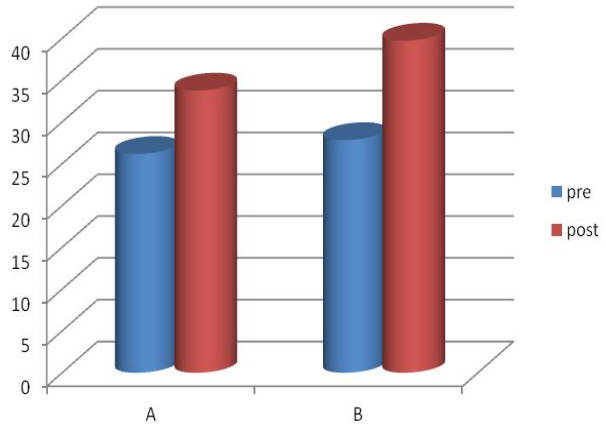
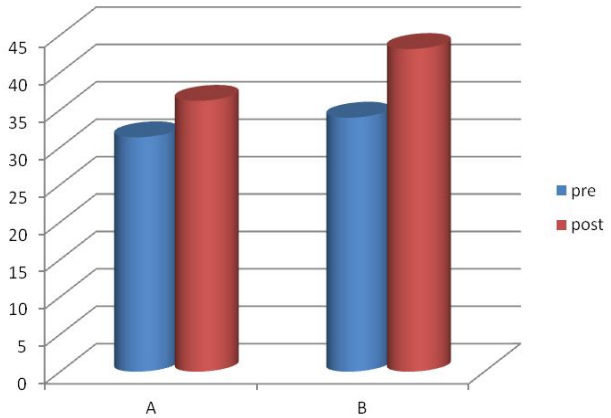


Figure 2: pre and post treatment mean values of peak torque of the knee extensors at (60 deg/sec) for both groups (A and B).



As revealed from Table (2 and 3) and from figure (1 and 2) significant improvement was observed in the post treatment mean values of peak torque of the knee flexors and extensors at (60 deg/sec) of both groups $P < 0.0001$, while table (4 and 5) and figure (3 and 4) show significant improvement in the post treatment mean values of peak torque of the knee flexors and

extensors at (120 deg/sec) of both groups at the end of treatment as compared with the corresponding mean value before treatment P < 0.0001. Table (6) and figure (5) show significant improvement in the post treatment mean values of the knee circumference above the knee of both groups at the end of treatment as compared with the corresponding mean value before treatment P < 0.0001.

Table 2: Post treatment mean values of peak torque of the knee flexors at (60 deg/sec) of groups (A and B).

	Group A		Group B	
	Pre	Post	Pre	Post
X'	26.18	33.76	27.84	39.73
±SD	±3.76	±3.58	±5.17	±4.25
T-test	8.81		9.91	
P-test	0.0001		0.0001	
Sig	S		S	

X2 : Mean, SD: Standard deviation, P-value: Level of significance, Sig.: Significance.

Figure 3: pre and post treatment mean values of peak torque of the knee flexors at (120 deg/sec) for both groups (A and B).

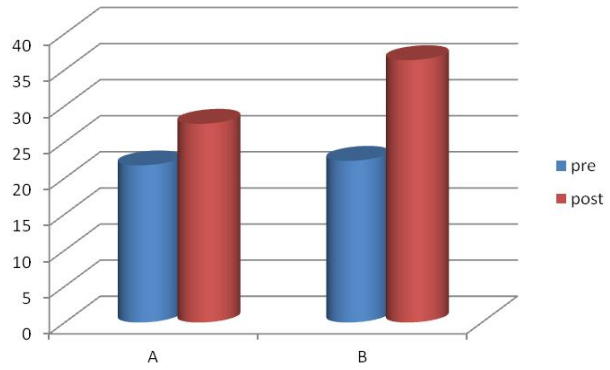


Table 3: Post treatment mean values of peak torque of the knee extensors at (60 deg/sec) of groups (A and B).

	Group A		Group B	
	Pre	Post	Pre	Post
X'	31.33	36.2	33.95	43.13
±SD	±4.06	±4.33	±7.18	±7.51
T-test	4.82		10.39	
P-test	0.0001		0.0001	
Sig	S		S	

Figure 4: pre and post treatment mean values of peak torque of the knee extensors at (120 deg/sec) of both groups (A and B).

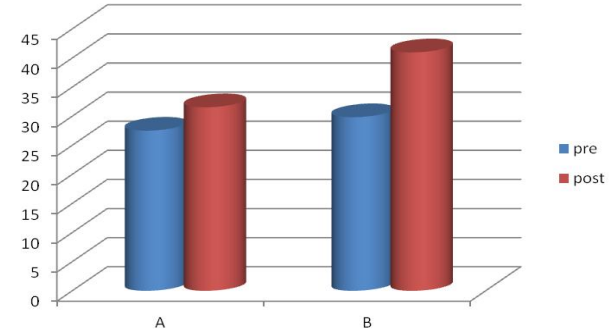


Table 4: Post treatment values of peak torque of the knee flexors at (120 deg/sec) of groups (A and B).

	Group A		Group B	
	Pre	Post	Pre	Post
X'	21.76	27.52	22.39	36.34
±SD	±3.89	±3.76	±5.33	±4.2
T-test	8.49		15.34	
P-test	0.0001		0.0001	
Sig	S		S	

Figure 5: pre and post mean differences of the knee circumference at mid patella for both groups A and B.

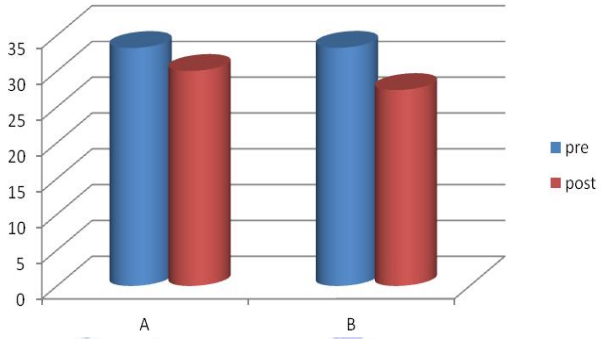


Table 5: Post treatment mean values of peak torque of the knee extensors at (120 deg/sec) of groups (A and B).

	Group A		Group B	
	Pre	Post	Pre	Post
X'	27.52	31.54	29.84	40.98
±SD	±3.69	±4.89	±6.53	±7.64
T-test	3.58		10.63	
P-test	0.003		0.0001	
Sig	S		S	

X2 : Mean, SD: Standard deviation, P-value: Level of significance, Sig.: Significance.

Table 6: Knee circumference above patella

	Group A		Group B	
	Pre	Post	Pre	Post
X'	33.23	30.03	33.26	27.36
±SD	±1.17	±1.39	±2.56	±2.27
T-test	12.66		23.18	
P-test	0.0001		0.0001	
Sig	S		S	

DISCUSSION

Hemophilic arthropathy affects a large number of hemophiliacs causing musculoskeletal problems, which affect the proper functioning of the locomotor system (joints and muscles). The most common affected joints are the hips and knees .The muscle-joint system degenerates with loss of muscle mass and strength, serious functional limitations and invalidity [24]. Heamarthrosis is a hallmark sign of hemophilia. The major sings of degenerative changes within

the affected joint are pain, swelling, loss of muscle mass, loss of range of motion and weakness [25, 26].Chronic synovitis with recurrent joint bleeds will create vicious circle of pain, swelling and weakness that will finally result in disability and decreased quality of life [27]. Following repeated bleeding the process of joint damage is progressive including muscle atrophy, osteoporosis, cartilage degeneration with collapse of the joint space, and cyst formation [28]. Joint heamarthrosis and hematomas cause muscle imbalance. Muscle imbalance may either result in overactive and tight muscle or inhibited and weak muscle [29]. The children participated in this study had unilateral heamarthrosis. A pervious study was performed to provide values on the muscular profile and establish normative parameters concerning muscular performance in professional soccer players using isokinetic dynamometer. The results of this study showed no significant differences have been observed in peak torque between the right and left lower limbs for the quadriceps or hamstrings at 60 deg/sec and 240 deg/sec.[30] Assessment of swelling of the affected joint was done by the tape measurement. Peak torque was assessed by Biodex System (Biodex Medical Systems, Inc, Shirley, New York). It is considered to be reliable instrument with reproducible data which quantify muscle function throughout the total range of motion at constant velocity that can be safely used in pediatrics. [30, 31]

After application of the designed exercise program, comparing the knee swelling above the affected knee in both groups there were significant reduction in round measurements also the mean values of the muscle peak torque of the quadriceps and hamstring muscles (at two different speeds 60 deg/sec and 120 deg/sec) of the control and study groups were increased. This can be attributed to the use of therapeutic ultrasonic and strengthening exercises. Therapeutic ultrasound affects the soft tissues by two mechanisms thermal and non thermal physical effects. The benefits of the thermal effect are increasing blood flow, decrease muscle spasms, increasing the pro-inflammatory response and also the collagen fibers extensibility increases. The pro-inflammatory response is achieved by gentle agitation of the tissue fluids which may increase the rate of phagocytosis and the movement of particles and cells. The non-thermal effect includes cavitations and acoustic micro-streaming. both are believed to alter cell membrane, structure, function and permeability which has been suggested to stimulate tissue repair [32,33]. Therapeutic ultrasound has a strong effect on the inflamed tissues through acceleration of fibrinolysis, stimulation of macrophages-derived fibroblast mitogenic factors, heightened fibroblast recruitment, accelerated angiogenesis, increased matrix synthesis, denser collagen fibrils, and increased tissue tensile strength.[32, 34]

Several studies have reported the importance of physical therapy exercises for hemophilic patients in improving joint stability through strengthening of the muscles surrounding the joint, reduced the frequency and severity of bleeding episodes than their sedentary peers [1,25,35]. Physical exercises are believed to modify coagulation parameters in those with mild to moderate hemophilia. In healthy subjects exercises have a beneficial effect on coagulation factors (increases factor VIII levels transiently) and so it helps to reduced factor usage and improved psychological well-being through feeling less dependent on medication [1,2,36]. Moreover when comparing the post-treatment mean values of both groups, it was found that there was a significant difference between the two groups at $P > 0.001$ in favor of the study group in all measured variables.

The result of the current study can be attributed to increase in muscle strength and reduction of knee swelling as a result of using treadmill training program in adjacent to traditional physical therapy program. Treadmill has positive effects in different clinical sittings and considered to have advantage on regular exercises [37]. Treadmill training was widely used in children with cerebral palsy. It is considered to be dynamic system approach that improves locomotion in cerebral palsy children. Treadmill training facilitates the kinematic, kinetic, and temporal features of walking. It is assumed to enhance motor learning and strengthen leg muscles, activate the locomotor control system, and improve functional abilities.[38, 39] Previous study revealed that, the treadmill training

improves the balance and build muscle strength in the lower limbs which are involved in the generation of more independent and mature walking [37]. Treadmill training is superior to regular gait training program as it eliminates the possible compensatory movement. In elderly with hemiparetic cerebral palsy treadmill training showed improvement in strength of knee flexors and extensors as well as dynamic balance [37]. Treadmill training is believed to improve the lower limbs muscle strength and balance as well as stimulate neuronal connections that are involved in generation of independent balanced walking [40]. Functional lower limb strength training combined with treadmill training are considered to be maximally effective than being applied independently [17]. Treadmill training has a superior effect on ground walking as it causes higher energy consumption when compared to energy consumption of over ground walking.[40]

List of abbreviations

Cm	Centimeter
Deg/Sec	Degree/seconds
F IX	Factor IX
F VIII	Factor VIII
HZ	Hertz.
Kg	Kilogram
MHz	Mega hertz
NY	New York
US	Ultrasound
USA	United states of America
V	Volt
W/Cm2	Watt/centimeter square

CONCLUSION

On the bases of the present data, it is possible to conclude that the application of treadmill training in addition to a designed physical therapy program is an effective therapeutic modality for improving muscle strength and functional activities in children with hemophilia.

Conflicts of interest: None

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