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Virtual reality versus whole body vibration on quadriceps muscle strength in children with thigh burn

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Abstract---Background: Burn is an injury caused by biological, chemical, electrical and physical agents with local and systemic repercussions. It is one of the most significant health problems throughout the world, leading to prolonged hospitalization and hence increased expense for the patients, their families and society. Today, the prognosis of patients with burn is dependent, apart from adequate treatment, upon the health-care system and health-care professionals, regarding not only survival, but also lifelong quality. Objective: this study was conducted to compare between the effect of virtual reality and whole body vibration as two methods of proprioceptive stimulation on quadriceps muscle strength in children with thigh burn. Subjects and procedures: forty children with unilateral thermal burn of the thigh ranged in age from six to twelve years participated in this study. They were divided randomly into two study groups I and II respectively. Study group I was treated by whole body vibration program in addition to conventional physical therapy program while the study group II was treated by a Wii-fit therapy program (as a form of virtual reality treatment program) in addition to the same conventional physical therapy program given to study group I. Treatment program for both groups was conducted for two successive months. Each child in both groups subjected to the same evaluation procedures using dynamometer for detection of

quadriceps muscle strength. Evaluation was conducted before treatment application and was repeated after 1st month (post1) and after 2nd month of treatment application (post2). Results: Both groups showed a statistically significant increase in quadriceps strength at post I and post II results when compared with pretreatment values ($p < 0.001$), while there was a statistically insignificant difference between the two groups post treatment ($p > 0.05$). Conclusion: Virtual reality and whole body vibration are equally effective in improving lower limb strength in children with thermal thigh burn with insignificant difference between the two modalities.

Keywords---Thigh burn, dynamometer, whole body vibration and virtual reality.

Introduction

Burn wounds are different in many ways from other wounds, and their treatment is generally more challenging in particular deep wounds that may lead to serious problems both in the acute and healing periods. Despite all improved modern treatment methods burn wounds constitute a serious problem in terms of morbidity as well as mortality also care of burn wounds necessitate a different kind of expertise. (1)

In a virtual reality (VR) program, human beings interact with a virtual space; this has the advantage of allowing movements of the subjects to be perfectly observed, evaluated, and controlled,, although the use of VR programs has been limited due to restrictive usefulness and the high cost of VR systems, they are especially useful in the field of physiotherapy because they enable repetitive exercise learning and allow a mechanism for providing proper incentives to patients who need feedback. Through this direct feedback, VR programs can not only provoke excitement but also enable users to develop a good sense of balance. (2)

Whole-Body vibration training (WBVT) on a platform has been suggested to be an appropriate intervention to improve muscle strength and body composition in order to counteract the loss of bone mass and muscle. The mechanical stimulus generated by this training method is transmitted to the body which, in turn, stimulates the sensory receptors (muscle spindles), activation of the sensory receptors results in the activation of the α -motor-neurons to contract the muscle, and it has been suggested that this mechanism via vibration is comparable to that of the tonic vibration reflex. (3)

Subjects and procedures

This Randomized controlled clinical trial (RCT) study design was conducted at Hehia Burning Institute (Sharkia Governorate) after the approval of the Ethical committee of faculty of Physical Therapy Cairo University No - P.T.REC/012/002171. Forty children of both sexes (25 boys, 15 girls) with 2nd

degree of thermal thigh burn ranged in age from 6 to 12 years participated in this study as shown in figure (1).

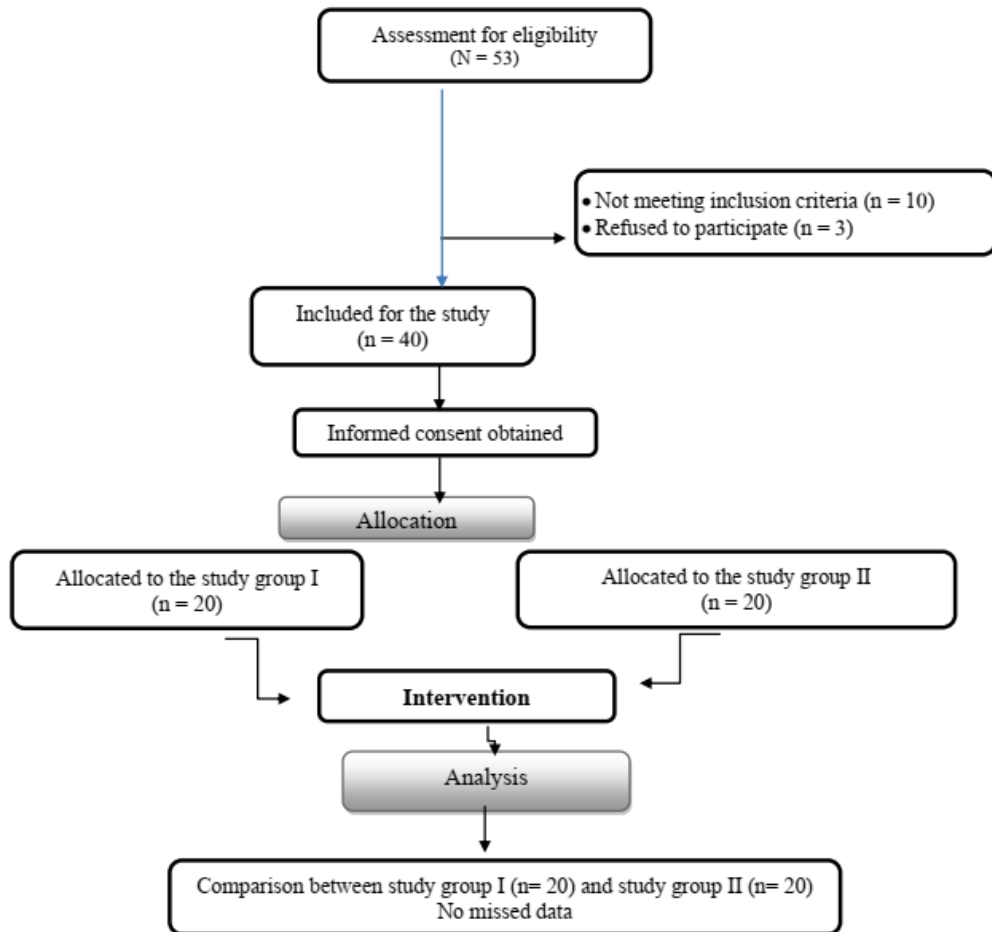


Figure 1. Flow chart showing the experimental design of the study

The selected subjects were divided randomly into two study groups of equal number I and II respectively using sealed envelopes. Study Group I (7 girls, and 13 boys) received whole body vibration program in addition to a conventional physical therapy program that was performed to improve lower limb strength and functional performance (including pulsed ultrasound and isometric exercises for the affected knee joint from supine position plus strength exercises for quadriceps and hamstring muscles from sitting and prone positions)

Children in Group II (8 girls, 12 boys) were treated by a Wii-fit therapy program as a form of virtual reality treatment in addition to the same conventional physical therapy program given to group I. The treatment was conducted for two successive months for both groups at a rate of three sessions per week.

Procedures

Assessment procedures

Assessment procedures were performed for each patient in both groups before and after the 1st (post 1) and 2nd (post 2) months of treatment application. Assessment of muscle strength was done by using Baseline Economy Mechanical Push/Pull Dynamometer by asking the child to sit erectly on a comfortable chair with both shoulders at the same level and back supported. Dynamometer was placed above the ankle joint and the child was asked to extend the knee as much as possible. (4)

- The test was repeated three times and the mean was calculated.

Treatment procedures

Children in both groups (I &II) received a conventional physical therapy program including:

pulsed ultrasound for 5 minutes for scar softening with intensity 3 Watts/cm², quadriceps exercises including isometric contraction, Stretching exercises for hamstring and calf muscles followed by Strength exercise for these muscles.

In addition to the previous conventional program children in **Group I:** received WBV after wound **healing**, from upright standing position with knees slightly flexed (to limit transmission of vibrations to the head) lateral oscillations of whole body was applied. Using hand bars to feel secure was allowed and the total duration of the WBV training was 30 minutes for three sessions per week for total periods of 2 successive months. (4)

For **Group II:** Children in this group were treated by Wii-fit therapy program (as a form of virtual reality treatment program) after wound healing for 30 minutes. Five groups of exercises were chosen including:

Muscle training exercise group

(Cycling exercise, Segway exercise, Tilt city exercise).

In Cycling exercise: the child was asked to step on Wii fit board and pedal a ride to work his/her lower body

In Segway exercise: the child was asked to stand in Wii fit board and to catch remote while concentrating in screen and trying to maintain balance. In Tilt city exercise, child stood in Wii fit board and tilt the wii remote and shift his/her weight on both lower limbs as seen on the screen

Yoga exercise group:

Warrior exercise: from standing in Wii fit board the child was asked to try to align thighs and hips and might also align pelvis as shown in the screen.

Standing knee: from standing in Wii fit board help the child was asked to lean in different direction as illustrated on the screen aiming to increase flexibility of the thighs.

sun salutation: the child was asked to stand in Wii fit board and try to flex both shoulder full range then extend back and recovery with flexed spine to the ground touch his toes

Muscle workouts group:

Sideway leg lift, Child stood in Wii fit board helped tighten the side and shoulder muscles for that well-toned look

Aerobic exercises group:

Step basics, Child stood on the ground and was asked to walk towards the Wii-fit board and took step per step on board as showed in the screen.

Balance exercises group:

Heading: Child stood in Wii fit board heading the balls as they are kicked and avoid other flying objects.

Balance bubble: Child stood in Wii fit board guide your mii safely down the river by leaning to the left, right, front and back.

Statistical Analysis

Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances. Unpaired t-test was conducted for comparison of the subject characteristics between groups. Chi- squared was carried out for comparison of sex distribution between groups. ANOVA with repeated measures was conducted for comparison of Quadriceps muscle strength pre treatment, post I and post II in each group and unpaired t test was carried out for comparison between groups. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA)

Results**Subjects' characteristics:**

Table (1) Characteristics of study groups I and II.

Table 1
Basic characteristics of participants

	Mean \pm SD		MD	t- value	p-value
	Study group I	Study group II			
Age (years)	8.95 \pm 1.82	9.1 \pm 1.91	-0.15	-0.25	0.8
Weight (kg)	27.14 \pm 3.92	28.25 \pm 6.73	-1.11	-0.63	0.52
Height (cm)	125.5 \pm 9.83	127.8 \pm 5.01	-2.3	-0.93	0.35
Sex					
Girls	11 (55%)	9 (45%)		(x ² = 0.4)	0.52
Boys	9 (45%)	11 (55%)			

SD: standard deviation; MD: mean difference; x²: Chi squared value; p value: probability value

Quadriceps muscle strength

Within group comparison

Within-group comparison revealed a statistically significant increase in Quadriceps muscle strength in both groups post I and post II when compared with pretreatment ($p < 0.005$) and a significant increase at post II compared with post I ($p < 0.005$) (table 2).

Between group comparison

There was no statistically significant difference between both groups pretreatment and post I post II ($p > 0.05$). (Table 2).

Table 2. ANOVA for Quadriceps muscle strength pre-treatment, post I and post II of study group I and II

	Pre treatment	Post I	Post II	p-value		
	mean \pm SD	mean \pm SD	mean \pm SD	Pre vs post I	Pre vs post II	Post I vs post I
Quadriceps muscle strength (kg)						
Study I	0.53 \pm 0.21	1.2 \pm 0.34	2.45 \pm 0.45	0.001	0.001	0.001
Study II	0.58 \pm 0.26	1.25 \pm 0.3	2.2 \pm 0.59	0.001	0.001	0.001
MD	0.05	0.05	0.25			
t- value	0.65	0.49	1.49			
p- value	0.51	0.62	0.14			

SD: standard deviation; MD, mean difference; p-value, Level of significance

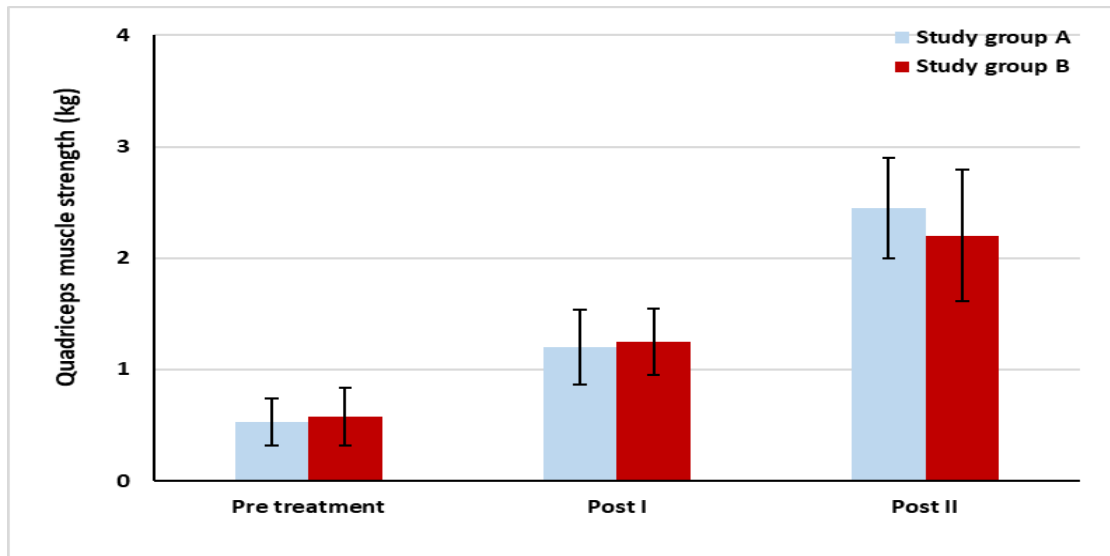


Figure 2. Mean Quadriceps muscle strength pretreatment, post I and post II of study group I and II

Discussion

The findings of the current study showed that both virtual reality and WBV significantly improved quadriceps strength in children with unilateral thermal thigh burn with no significant difference between the two proprioceptive stimulation modalities.

Whole body vibration had shown improvement in knee extensor strength in study group I which comes in agreement with Gomah 2018, (4) who found that WBV is an effective alternative tool to resistance training as WBV appeared to elicit neural changes, he also reported an increase in muscle strength in patients who treated by WBV more than those who received traditional physical therapy exercise program in the absence of vibrations after 8 weeks of treatment application.

Improvement in knee extensor strength following WBV is also supported by Ebid 2012, who reported that WBV exercise resulted in improved muscle strength when compared to gains with moderate resistance training as WBV is associated with reflex muscle activity and not only the body-weight exercises (6)

Improvement in study group II may be attributed to the effect of using VR which may enhanced the child active participation by being involved in an attractive game which may in turn alleviated pain sensation as pain is a subjective and individual experience related to physical factors the collaboration of the patients in activities that improve their quadriceps muscle strength during wii fit exercise. (5)

The results of the current study showed that VR, can be considered as an adjunct treatment for burned children which may be supported by Hui-Ting Lin

et al, 2019, who performed game screening pelvic movements as forward, backward, lateral tilt movements, and go around motions according to the easy-to-understand which resulted in increase in the contraction of quadriceps muscle with instructions provided by the Wii game screen. Movement imitation may make it possible for patients to understand how to control their pelvic motion, and the exercises may promote the strengthening and relaxation of the waist muscles and ligaments as the child was always trying to keep the body continuously aligned correctly and at the same time, the patients can clearly see their posture on the screen. ⁽⁸⁾

It may be suggested that VR had a potential beneficial effect for making active ROM exercises more comfortable and enjoyable for patients even if reduced pain does not translate immediately into greater ROM, as patients found exercises less painful and more enjoyable they liked to participate more and longer in therapies, which may ultimately resulting in better long-term outcomes. ⁽⁹⁾

Conclusion

Virtual reality and whole body vibration are equally effective in improving lower limb strength in children with unilateral thermal thigh burn and it is advised to include them in rehabilitation of children with burn.

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