User Centered Portable Suspension Therapy Unit Design & Testing on Healthy Volunteers

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Abstract

Background: Suspension is a therapeutic skill that suspends a body and eliminates effects of friction to ease the movements. It is very beneficial in both musculoskeletal and neurological field.

Objective: To make suspension therapy more accessible for a physiotherapist domestically which provide an opportunity for patient to receive suspension therapy in any occasion.

Study Design: Pilot study.

Sample Size: 30 healthy subjects from Hospital or AIMST University (with various body sizes).

Discussion: The overall satisfaction level for the Portable Suspension Kit is pleasant. The subjects acknowledge that suspension therapy helps to improve range of motion and is suitable for home rehabilitation and both statements score the highest which is 3.9667±0.66868 out of 5. On the contrary, the subjects agree less on the stability of the frame which results show 3.7±0.98786 out of 5. Whereas, for R.A. tracker, the outcome of accuracy level turned out to be 65.2% which is of moderate range and the result is acceptable for a new prototype. $P > 0.652$ is not statistically significant due to the sensor sensitivity of calibration. Thus, we strongly agree that the deficiency needed to be improved to allow accurate visual feedback.

Conclusion: The making of 'Portable Suspension Kit' is successful and indeed is convenient to carry around. Suspension therapy can now be widely used in any occasion on the patients. Nevertheless, it still has more to improve especially on the stability and the material used to make it safer, lighter and easier to carry.

Introduction

Suspension therapy is very beneficial in both musculoskeletal and neurological field; it has some disadvantages which are yet to be overcome. It is big, heavy and immobile causes it impossible to Transport and limit the suspension exercise only to a specific location. In medical search engines such As Pub Med, NCBI, and Medscape is lack of information and article for sling suspension Therapy[1]. This may be due to suspension therapy is not widely used in the medical field as it requires

More time to set up the slings and cuffs. Besides, this topic is overlooked[2]. Although had some research did the research or study, most of them were focused on low back pain or urinary incontinence, which was lack of information focus on musculoskeletal and neuromuscular[3.] Suspension therapy also known as sling therapy is one of the therapeutic technique where a part of the body is supported by a sling and suspended by ropes to the fixed point on suspension frame[4]. It frees the body from friction and helps to move the body easier with less resistance. (John George B, 2002)[5]. Hence,

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this helps the patient in reducing the axial load on the joint while the patient is performing the exercises. Suspension therapy can be either used as an assistance exercise or resistance training[6]. There are 3 main principles used in suspension therapy which is friction, pendulum and eliminating gravity movements. Firstly, fiction is produced when a particular surface moves on another. In suspension, friction is less, therefore causes smoother and easier movement. Secondly, a pendulum is a heavy material suspended by a weightless thread. When the force is applied to the pendulum it results in movement[7]. In the human body, pendular motion occurs mainly at the shoulder and hip joints, forward leg movement and arm swing while walking[8]. This helps to maintain muscle properties, increase range of motion and strengthen the muscle. Lastly, it comes to eliminating gravity movement, the patient should at least have muscle power grade 2 for suspension exercise[9]. The therapist is able to alter the patient's position while doing the exercise[10]. The accessories used in suspension therapy, e.g. suspension frame, connecting rope, wooden cleat, dog clip or S-hook and spring. Connecting ropes provide attachment for a sling to the steel and able for adjustment in length[11]. Though its effect such as strengthening muscle, increase range of motion, and improve coordination are similar to those of other forms of exercise[12], additional characteristics of suspension therapy make it[13] particularly useful and unique. Other than those mentioned[14], the suspension also helps to improve stability of the joint, stimulate the sensorimotor system and improve patient confidence to undergo exercise or rehabilitation programme[15].

Method and Subjects

A qualitative research model in the form of a prospective type quasi experimental study design is carried out in this study. The study is conducted in collaboration with AIMST University Malaysia, University of Indonesia, NMT Institute Italy & USA, Institute of Paramedical Sciences, Kannur, India and Mekelle University Ethiopia. In this study all Academic and non-academic professionals are the population for this study. Conveniently 800 participants among the academic professionals are selected in collaboration with AIMST University Malaysia, University of Indonesia, NMT Institute Italy, USA, and Mekelle University Ethiopia & Institute of Paramedical Sciences, Kannur, India.

Standard Application procedure: Patients diagnosed by Low back and neck pain for at least 6 months,

Features: Width Cm 5 and Length 30 cm.

Reference points: Intergluteal line - Vertebral column.

Patient standing with hands resting on a table, anterior lumbar flexion of 45°. Apply the base of the tape on the interglutea line and laterally 2 cm from the vertebral column. Remove the paper leaving only a small piece to hold the strip. Ask the patient to round the lumbar section (ask to "pull in the belly", the skin over the lumbar area must be stretched). The tape is applied with absolutely no tension[16]. The tape is applied parallel to the column and must end at exactly the same level. The treatment was given twice per week for 6 weeks (8-10 sittings). The cure tape is approved by the FDA and the product name is Tape and bandage, adhesive. Before the primary neuromuscular taping application VAS (visual analogue scale for pain scaling) and back pain index (Oswestry Low Back Pain Disability Questionnaire) were collected and this procedure was continuing till the end treatment sessions. This portable suspension kit is invented to help the physiotherapist to make use of the suspension therapy domestically. Because we found out that there is difficulty in applying suspension therapy in a ward, home-based rehabilitation and nursing house[17]. The difficulties are due to the large size and heavy weight of the suspension frame which make it not portable and mobile. The new invention portable suspension kit is foldable and light in weight which can be carried by the physiotherapist. It can follow the patient wherever he is and can be easily kept. It offered a portable and mobile frame to perform the suspension therapy in need of the patient which is very beneficial in the rehabilitation progression. The reason why we are inventing a R.A tracker is to calculate the repetition and accuracy of the patient performing the movement instructed which is very important for the outcome of the rehabilitation. Setting a target for a patient to complete can be a motivation in rehab. Sometimes, they may get bored, sleepy and during exercise and forget in counting the repetition. Hardship may be felt during rehab, so patient sometimes will find excuses for not completing the exercise that is given[18]. This tracker is now useful in this case by helping them calculate the repetition when they are performing the exercise and cheating is prevented because a repetition can only be counted as one when u reach a targeted angle and during back to starting position

it should be less than 5 degrees. Repetition is important during rehabilitation because the neuronal circuits can be changed by the neuroplasticity in the brain's ability. For example, increasing the amounts of the task repetitions proved that it can help in cortical changes and functional improvement in a post-stroke patient. The main point to focus on rehabilitation professionals should be the number of repetitions and the type of activity performed per session. According to the current research shows that most of the physiotherapy session does not contain the proper and sufficient amount of repetitions in each session to cause actual changes in the brain. Thus, one item of focus for rehabilitation professionals should be the number of reps and type of activity performed in each session. Current research, however, shows that most therapy sessions do not contain the proper amount of repetitions per session to cause actual changes in the brain. Typical therapy sessions, whether physical, occupational, speech, or behavioral, last about one hour per session with the therapist employing various tasks and exercises throughout the session[19].

Methodology

The study duration is about one year and treatment duration is one treatment twice a week with 30 minutes per session which held at AIMST University Physiotherapy Clinic and private clinic with the size of 30 samples from AIMST University Physiotherapy clinic and private clinic. The sample was contacted twice a week and one treatment session is 30 minutes.

Results

Table 1: Sample Characteristic

	Frequency	Percentage
Gender		
Male	15	50%
Female	15	50%
Age Category		
21 - 30	13	43.3%
31 - 40	9	30.0%
41 - 50	4	13.3%
51 - 60	2	6.7%
61 - 70	1	3.3%
70 - 80	1	3.3%
Weight Category		
Less than 50 kg	4	13.3%
51kg – 70kg	12	40.0%
71kg – 90kg	9	30.0%
91kg – 110kg	5	16.7%
More than 110kg	0	0%
Height Category		
Less than 150cm	2	6.7%
151cm – 160cm	4	13.3%
161cm – 170cm	8	26.7%
171cm – 180cm	12	40.0%
More than 180cm	4	13.3%

Table 1 shows this demographic characteristic of samples participated in this study. In this study, consists of 15 male and 15 female as a sample with a percentage of 50% respectively. The sample was divided into 6 groups in the age category. Between the age of 21 to 30 consists of 13 samples (43.3%); 9 samples (30.0%) in the age between 31 to 40; 4 samples (13.3%) in the age group within 41 to 50; 2 samples (6.7%) with age range from 51 to 60; the age group with the range of 61 to 70 and age within 71 – 80 only have 1 sample each (3.3%). We divided the weight category into 5 groups. We have 4 persons (13.3%) in the group with a weight of less than 50kg. weight range from 51kg to 70kg is 12 persons (40.0%) from the weight range from 51kg to 70kg; 9 samples (30.0%) from the weight group of 71kg to 90kg and 5 samples (16.7%) from the last weight group with the range of 91kg to 110kg. In this study, we did not include any sample with the weight that exceeds 110kg. There were 5 different groups divided in the height category. For the height less than 150cm consists of 2 samples (6.7%); 4 samples (13.3%) with the height range of 151cm to 160cm; 8 samples (26.7%) with the height range of 161cm to 170cm; 12samples (40.0%) with the height range from 171cm to 180cm and 4 samples (13.3%) with the height more than 180 cm. Table 5.1 shows the weight, height and after 4 sessions of 2 weeks treatment samples satisfaction level on pain relief, range of motion, muscle strength, home rehab, and stability. The mean weight value of the samples is 69.0667±18.69710 and the mean height of the samples is 169.3000±11.16383. The average satisfaction level on pain relief is 3.8333± 0.59209; improving in range of motion is 3.9667±0.61495; improving in muscle strength 3.8000±0.66436; for home rehabilitation purpose is 3.9667±0.66868 and stability of the frame is 3.7000±0.98786. Table 5.2 shows the correlation

between weight, height, and stability. The correlation test shows that body weight is significantly related to height (r= 0.851, P< 0.01). In comparison between body weight and stability, r= -0.692 which demonstrates that body weight is significant to stability (P< 0.01). In regards to the correlation between height and stability, the result depicts the coefficient -0.652 which clearly shows that height is significant to stability (P< 0.01) in figure 1.0 which is the receiver operating characteristic (ROC) graph with the angle of movement against repetitions. In table 5.3 the result demonstrates the area under the curve is 0.652. The percentage of the sensitivity is 65.2% and the result of the area under the curve is not statistically significant (P> 0.05). Even though the result is not significant but it is still considered moderate and acceptable. The coordinates of the curve in table 5.4 shows that if the test results can be improved to 27.5 % than the sensitivity can be enhanced to 96 %.

Table 2: Descriptive state of weight, height and satisfaction level on pain relief, range of motion, muscle strength, home rehab, and stability.

Variable	Mean	Std. Deviation
Weight	69.0667	18.69710
Height	169.3000	11.16383
Pain relief	3.8333	0.59209
Range of motion	3.9667	0.61495
Muscle strength	3.8000	0.66436
Home rehab	3.9667	0.66868
Stability	3.7000	0.98786

Table 3: Correlation between weight, height and stability.

	Mean	Std. deviation	1 Body Weight	2 Height	3 Stability
Body Weight	69.0667	18.69710	1	0.851**	- 0.699**
Height	169.3000	11.16383	0.851**	1	- 0.692**
Stability	3.7000	0.98786	- 0.699**	- 0.692**	1

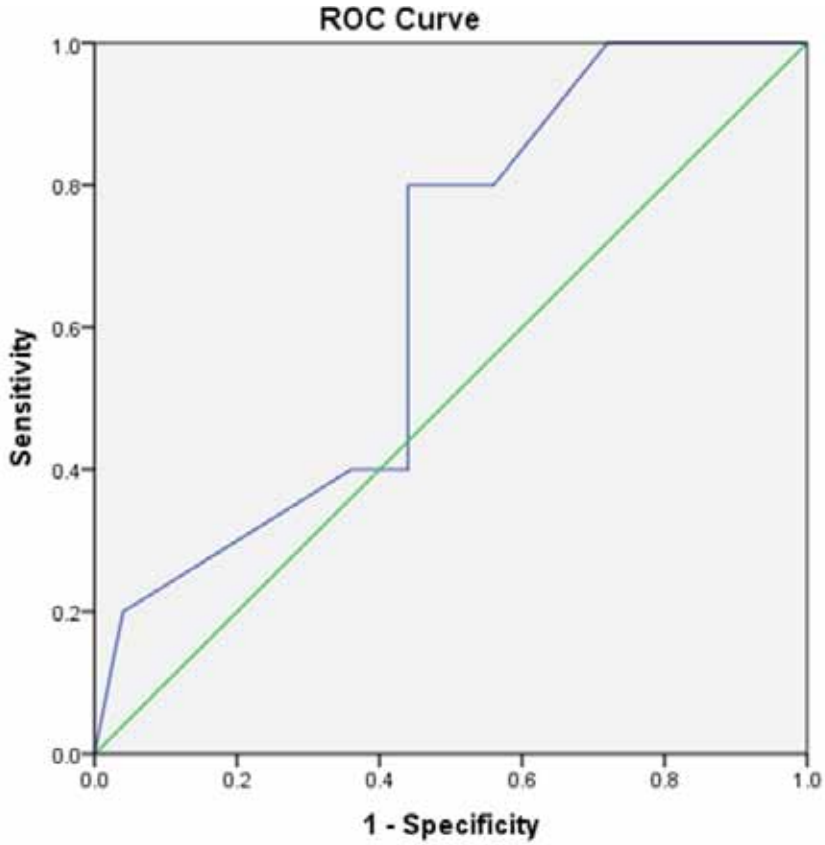

Figure 1: Receiver operating characteristic (ROC) curve of the angle of the movement against repetitions.

Table 4: Shows the area under the curve with the angle of movement as the test variable.

Test Result Variable(s): angle of movement		
Positive if greater than or equal to	**Sensitivity**	**1-Specificity**
24.0000	1.000	1.000
27.5000	.960	.800
32.5000	.640	.600
37.5000	.560	.600
42.5000	.560	.200
47.5000	.440	.200
52.5000	.280	.000
57.5000	.200	.000
62.5000	.120	.000
67.5000	.080	.000
72.5000	.040	.000
76.0000	.000	.000

Table 5: Coordinates of the curve

Area	Std. Error	95% Confidence Interval		P
		Lower Bound	Upper Bound	
0.652	0.120	.416	.888	0.290

Discussion

The 'R.A. Tracker' is advantageous for physiotherapists in decreasing the workloads, the mission of counting the repetition and observing the angle can now be done by the tracker. It alleviates the burden on the physiotherapists so that they can pay attention to observing any secondary movement or the appropriate muscle action. The tracker uses battery-powered liquid-crystal display (LCD) as display of the device. The repetitions and angle can be pre-set which makes the treatment effective by providing biofeedback to the patient. This allows the patient as well as the therapist to be aware of the quantity and quality of the movements, at the same time enables the therapist to set a target to the patient. In general, the 'Portable Suspension Unit' performs a more professional appearance in contrast to the traditional suspension therapy. During the trial of the R.A. tracker, 15 repetitions of specific movements are prescribed to the subjects. The examiner was beside the subject comparing the exact movement and angle while comparing it to the tracker. The outcome turned out to be 65.2% which is in mid-range. The accuracy is acceptable for a new prototype. There are many reasons that caused it to be less precise and further enhancement is needed to make it more perfect. $P > 0.652$ is not statistically significant due to the sensor sensitivity of calibration. Sensitivity is significant as it refers to the input signal required to project the output of the device and it shows the true positives in some situations. Therefore, its deficiency needed to be improved to allow accurate visual feedback. The calibration process takes time due to the Auto-Calibration process in the Digital Motion Processor (DMP) itself. The DMP uses an algorithm to Auto Calibrate the values over time.

This time varies across each MPU6050 sensor as there is a slight variation and offset in the sensor due to the manufacturing process. This would affect the speed of the auto-calibration process. One way to improve the auto-calibration speed is to supply an offset for the sensors prior to the auto-calibration. The offsets are unique to every MPU6050 sensors due to the manufacturing process and slight variations in each sensor. (V. Christ, 2017) the sensor becomes less accurate over time due to gyro drift in the gyroscope within the sensor. The gyroscope has an internal bias or noise within the sensor. The bias or noise changes over time due to various factors such as temperature or just an inherent noise in the sensor. Hence when the raw values are fed into the DMP it would auto-calibrate based on the current bias or noise.

Conclusion

In conclusion, we found out that suspension therapy still very high demanding for rehabilitation treatment in our country no matter in hospital, private clinic, etc. through our survey, the heavy, big and immobile suspension frame brings a lots of inconvenience for the physiotherapist who wish to do home rehabilitation, ward and for patient with difficulty in ambulation and more. The survey result shows that the majority agreed that suspension therapy brings tons of benefits to the patient and our invention The Portable Suspension Unit will help in fulfilling their needs for domestic purpose. We also gained some bits of advice from the minority which not satisfied with our invention. From here we'll have more discussion and enhancement regarding the limitation of our portable suspension kit and take into consideration to make changes such as the design, materials, and weight to make it more convenient and functional.

Ethical Clearance: No ethical approval is needed.

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Conflict of Interest: Nil

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