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TOLERANCE OF A TILT TABLE PROTOCOL IN AN IN-PATIENT STROKE UNIT SETTING: A PILOT STUDY

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Abstract

Background and Purpose—To describe and examine physiological and self-reported indices of tolerance to a standing tilt table protocol (STTP) among patients following an acute stroke.

Methods—We undertook a prospective, observational pilot study of patients admitted to a stroke unit of a single academic medical center. A clinical protocol for the use of the tilt table was developed and applied to subjects in the acute phase following a stroke. The protocol involved a step-wise process to gradually raise the subject into a standing position on the tilt table platform, at 10 degree intervals from 60 to 90 degrees. Overall, tolerance of the STTP was defined as the ability to sustain 60 degrees or greater of tilt table inclination for a minimum of 5 minutes, without signs or symptoms of intolerance. Specifically, frequencies of the highest angle achieved, the duration of standing time tolerated, and physiologic response were recorded.

Results—Thirty-six patients with ischemic or hemorrhagic stroke (22 females, 14 males) aged 24 to 87 years (62, SD = 16 years) participated in a single trial of the STTP. Fifty three percent of subjects (N = 19) attained 60 degrees or higher on the tilt table, with a mean total standing time of approximately 9 minutes.

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LIST OF SUPPLEMENTAL DIGITAL CONTENT

Supplemental Digital Content 1: Video Abstract.mp4

Supplemental Digital Content 2: Tilt Table Methodology.mp4

A poster presentation of this work was presented at the James Rae Scientific Day for residents of Physical Medicine and Rehabilitation at the University of Michigan Hospital in May, 2011.

A poster presentation of this work has been accepted to the APTA Combined Sections Symposium scheduled for February, 2012. A poster presentation has been accepted by the American Heart Association International Stroke Conference 2012.

Conflict of Interest: none declared

Discussion and Conclusions—This pilot study suggests that use of a tilt table is well tolerated among patients in the acute stroke phase, and may be an effective tool for introducing early mobilization to a medically fragile patient population. **Video Abstract available** (see Video, Supplemental Digital Content 1) for more insights from the authors.

INTRODUCTION

Physical therapists (PT) employ multiple methods to limit the effects of bed rest, to address the primary deficits of stroke, and to facilitate maximal functional recovery. Often, an eclectic treatment approach is provided based on individual therapist's strengths and philosophy, as well as patient presentation and tolerance. However, with this approach, it is difficult to identify a best practice that has the greatest impact on patient outcomes.¹ The American Stroke Association 2011 stroke statistic update indicates that 795,000 people will have a new or recurrent stroke each year and 7 million Americans, over the age of 20 years, have already had a stroke.² On average, every 40 seconds someone will experience a stroke. Of all strokes, 87% are due to ischemia, 10% are due to intracerebral hemorrhage and 3% to subarachnoid hemorrhage.³

Following stroke and during hospitalization, patients who are unable to safely stand and perform independent transfers are at an increased risk for multiple medical complications.⁴ Roth et al.⁵ report that 75% of rehabilitating stroke patients experience at least one medical complication during their inpatient hospital stay. The most common complications during the first week following stroke are pain, fever (temperature > 38 degrees C), stroke extension, urinary tract infection, non-serious falls, and myocardial infarction.⁶ Non-ambulatory patients also have an increased risk for DVT or pulmonary embolus⁷ and complications from immobility account for up to 51% of deaths in the first 30 days after ischemic stroke.⁸

Despite knowledge of the benefits of mobility for hospitalized patients, multiple barriers exist to early mobilization. Those barriers may include: 1) concern for hemodynamic instability due to acute medical condition; 2) impaired level of consciousness affecting participation; 3) hospital personnel time constraints due to increased non-clinical patient care responsibilities;⁴ and 4) concern for increased patient fall risk or physical injury to staff/caregiver during assisted transfers.

Patients hospitalized within a stroke unit often have impairments that prevent them from safely transferring out of bed. In a large, multi-centered trial of very early mobilization (VEM) within the first 24 hours of stroke, Bernhardt et al.⁹ demonstrated that VEM, which consisted of "assist[ing] the patient to be upright and out of bed (sitting or standing as able) at least twice per day; in addition to their usual care" appears safe and feasible. Additionally, VEM was found to improve overall function, reduced time for return to unassisted walking (3.5 days versus 7 days for controls),¹⁰ and increased the likelihood of discharge directly to home from a combined acute inpatient rehabilitation stroke unit.¹¹

While in the acute stroke phase, concern regarding hemodynamic variability and its effect on cerebral blood flow may predispose patients to prolonged bed rest. There are theoretical concerns based on transcranial doppler studies^{12–13} that upright positioning could result in infarction extension due to lowering blood pressure within the ischemic perilesional region (penumbra), where dysfunctional autoregulation of cerebral blood flow may occur. However, additional studies have been inconclusive,^{14,15} and it is still unclear whether slowed cerebral blood flow velocity leads to an extension of the infarct core or further injury of the penumbra. The volume of preserved penumbral tissue has been significantly related to spontaneous neurological recovery following stroke.¹⁶ It is the penumbra, the moderately

hypoperfused, non-functional but still viable brain tissue surrounding the irreversibly damaged ischemic core,¹⁷ that may be susceptible to altered hemodynamics, and therefore any risk of injury to this area should be avoided at all costs.

Clinically, the use of a tilt table is a recognized rehabilitation tool to aid upright standing activity. Empirical evidence suggests that the use of a tilt table is an effective means to address barriers within the intensive care unit.¹⁸ Studies have proposed that the benefits of upright mobilization include improved bone density, cardiopulmonary function, gastrointestinal motility, reduced pain, and improved functional recovery following stroke.⁴ A review of the research shows that repeated head-up tilt table use may be effective in the treatment of orthostatic intolerance¹⁹ and spasticity.²⁰ The use of a tilt table can maximize the potential for longitudinal weight bearing through the lower extremities in a position of hip extension with concurrent knee extension and ankle dorsiflexion that is not obtained in the seated position. Additionally, this position may serve as the basis for future task-specific standing balance and gait training.

A review of the literature reveals limited research regarding potential risks or benefits of using a tilt table specifically to assist patients into a standing position. Korpelainen et al.²¹ examined the response to a tilt table intervention on patients who were 2 – 10 days poststroke. This group found no significant difference in peripheral blood pressure readings after standing at 90 degrees for 7 minutes. Panayiotou et al.¹⁵ examined hemodynamic responses to an intervention consisting of 5 minutes of sitting followed by 5 minutes of standing in participants 3 – 10 days poststroke. The incidence of intolerance (defined as a drop of systolic blood pressure greater than or equal to 20 mmHg) was 3% – 19% for participants post-stroke and 8% – 18% for the control group.

Beyond these two studies, information on use of a tilt table as a means to assist patients into a standing position acutely after stroke is lacking. Additionally, bed rest within the first 24 hours following stroke continues to be recommended.¹⁴ To address this gap in knowledge, we proposed a study to examine the tolerance of a progressive standing tilt table protocol (STTP) designed to facilitate lower extremity weight bearing early after stroke.

The primary aim of this pilot study was to assess the hospitalized patient's physiologic tolerance to standing while on a tilt table following an acute stroke. Furthermore, in order to determine a clinically applicable standing tilt table protocol, we assessed the tolerance of maximal angle of tilt achieved and associated duration of standing time.

METHODS

Sample Characteristics

This study was conducted within an adult acute stroke care unit at the University Hospital in Ann Arbor, Michigan. Participants eligible for this study were: 1) adults 18 years or older; 2) admitted to the stroke unit; and 3) currently diagnosed with ischemic or hemorrhagic stroke. There were no restrictions of participation based on location or etiology of lesion, or severity of clinical deficits. As this pilot study was designed to assess the safety and physiologic tolerance to a standing tilt table protocol, and to generalize the results across varying levels of neurological insult, stroke severity or functional status was not considered to be an inclusion or exclusion criteria as a parameter for this study. Exclusion criteria included: 1) strict bed rest orders, 2) tissue plasminogen activator (tPA) or thrombolytic administration within the prior 24 hours, 3) past medical history of recurrent syncope, 4) current lower extremity fractures, and 5) weight exceeding 750 pounds, due to equipment limitations.

Participants were recruited through screening of consecutive admissions between September 1, 2008 and December 31, 2009. The Institutional Review Board of the University of Michigan Medical School approved this study and written informed consent was obtained from all participants or their proxy.

Tolerance Parameters

The STTP clinical indices of tolerance were operationally defined as: 1) systolic blood pressure (SBP) maintained within 20 mmHg of baseline; 2) diastolic blood pressure (DBP) maintained within 10 mmHg of baseline; 3) heart rate (HR) maintained within 10 beats per minute of baseline; 4) oxygen saturation (SpO₂) maintained at 90% or above while on supplemental O₂ or room air; and 5) clinical observation of dyspnea or pallor. The Marquette Solar 8000-M Telemetry unit (GE Marquette Medical Systems, Inc., Milwaukee WI) was available in each participant's room to collect SBP, DBP, HR and SpO₂.

Subjective indices of tolerance were operationally defined as: 1) rating of perceived exertion (RPE) 15 as measured by the Borg Rating of Perceived Exertion Scale²² 2) pain 5 using a numerical pain rating scale ranging from 0 (no pain) to 10 (extreme pain), 3) absence of angina, dizziness, or nausea, and 4) request to discontinue the STTP. When subjective indices of tolerance could not be verbally communicated by a subject due to cognitive or sensorimotor deficits, other clinical signs of distress such as facial grimace, gesturing, or diaphoresis were used.

Due to the exploratory nature of this study, tolerance or lack thereof was defined by multiple measures of both objective clinical indices and subjective report. No single measure was considered to be of primary importance, and any value falling outside the predetermined parameter was considered indicative of intolerance. Overall, the primary outcome of the STTP was defined as the ability to sustain 60 degrees or greater of tilt table inclination for a minimum of five minutes, without signs or symptoms of intolerance.

Standing Tilt Table Protocol (STTP)

Each participant underwent one session of the STTP. Baseline measurements were taken while participants were at rest for a minimum of 10 minutes in the hospital bed, with 30 degrees of head elevation prior to transfer to the tilt table. A tilt table (Tri W-G Motorized Bariatric Tilt Table, Model #TG2732; TRI W-G, Valley City, North Dakota) was used. The specifications included a 750-pound weight capacity, electric hand controller of tilt range 0 – 90 degrees, and included safety belts, foot plate, and angle indicator.

The STTP was implemented in the participant's hospital room. The tilt table was positioned parallel to the participant's bed and the height of the bed was adjusted until the two surfaces were level with each other. Clinical and subjective indices were assessed prior to transfer (baseline measurement) and at each subsequent angle of inclination. A safety check was performed by observation and adjustment of all indwelling lines to prevent disruption: 1) prior to draw sheet technique transfer to the tilt table and 2) at each subsequent step-wise angle of inclination (see below).

Participants were secured to the tilt table and elevated to 45 degrees for five minutes, and clinical and subjective indices for tolerance were assessed at three minutes within the five minute interval (please see Video, Supplemental Digital Content 2 which demonstrates step-wise progression of the tilt table protocol). If signs and symptoms of intolerance (described as above) were present, participants were returned to a resting position in the hospital bed, vital signs were again assessed, and the nursing staff was notified. Successful completion of 45 degree elevation resulted in a stepwise progression to 60, 70, 80 and 90 degrees for a maximum duration of 20 minutes at or above 60 degrees, for those participants who

demonstrated tolerance. If signs of intolerance were observed at any angle of inclination, the protocol was terminated and participants were returned to a horizontal position at the rate of 3 degrees per second specific to the mechanical properties of the tilt table. The participant was then returned to a recumbent position in bed and vital signs were re-assessed.

Statistical Methods

Analyses included descriptive statistics (mean, standard deviation [SD] and frequency) for sample characteristics, maximum angle achieved, and clinical and subjective intolerance parameters. Chi square analyses were used to test differences between categorical observed and expected values.

RESULTS

Study Participants

One hundred fifty-one patients consecutively admitted to the stroke unit were screened for this study. Of the 84 patients who met inclusion criteria, 51 were enrolled in this study. Of those enrolled, 38 participants participated in the STTP. Those who were enrolled but did not complete the study were either discharged prior to participation (N=11), withdrew consent (N=1), or experienced a change in medical status (N=1) prior to the initiation of the STTP. Two participants were initially diagnosed as having a stroke and underwent the STTP. Their diagnoses were later revised, and therefore these data were excluded, therefore data from 36 participants with stroke were included.

The average age of study participants was 61.72 (SD =16, range = 24 – 81) years of age. Twenty-two (61%) of the participants were women, 25/36 (69%) of the strokes were ischemic. A retrospective discharge summary review indicated that 18 participants had a stroke in the cerebrum, 2 in the cerebellum, 13 in the brainstem and 3 were unknown. The average length of stay was 7 (SD=5) days and 19 participants (53%) were discharged to home. Seventeen participants (47%) were transferred to acute or sub-acute rehabilitation care.

Maximum Angle Achieved

Nineteen participants (53%) were able to maintain 60 degrees or more of tilt for at least five minutes without signs or symptoms of intolerance as operationally defined by this protocol as illustrated in Table 1. There were no significant differences in maximum angle achieved between those diagnosed with ischemic or hemorrhagic stroke ($\chi^2 = 0.00$, $p = 0.983$). Ten participants were unable to tolerate standing at a 45 degree angle.

Clinical and Subjective Indices of Tolerance

Angina, dyspnea, SpO₂ and pallor did not exceed thresholds outside the protocol parameters for participants at any angle as indicated in Table 2. The most frequent reason for terminating a trial was SBP and DBP variation outside the STTP parameters. This was consistent across all angles. At 45 degrees and 60 degrees of inclination, 1 participant and 2 participants respectively, experienced a heart rate change outside the parameters of the protocol, while subjective indices of dizziness and nausea were both infrequently and inconsistently reported at 45, 60 and 80 degrees.

Time from Admission to Implementation of STTP

There was not a significant relationship between tolerance of the STTP above 60 degrees and the time between admission to the unit (categorized as < 24 hours, 24 – 48 hours, 48 – 72 hours and > 72 hours) and initiating the STTP ($\chi^2 = 5.964$, $p = 0.113$). There appeared to

be some advantage in waiting 24 hours after admission before implementing the protocol, as tolerance appeared to be greater for those participants who initiated STTP after this time. This result should be interpreted cautiously without replication. It should also be noted that time of admission does not necessarily indicate time of onset of stroke, as there can be large time lapse from symptom onset to hospital admission.

DISCUSSION

This pilot study shows that the majority of acute stroke patients in our sample demonstrated physiologic, clinical, and subjective tolerance to a standing tilt table protocol (STTP) intervention. Fifty-three percent of subjects attained 60 degrees or higher, with a mean total standing time of 8.9 minutes. The most common factor for terminating a trial at any angle was exceeding the allowable diastolic blood pressure parameters.

In comparison to use of a tilt table to assess physiological response to upright activity follow stroke, Panayiotou et al.¹⁵ examined hemodynamic responses to an intervention of 5 minutes of sitting followed by 5 minutes of standing in participants 3 – 10 days following admission after stroke. The incidence of intolerance (defined as a drop of systolic blood pressure greater than or equal to 20 mmHg) was 3 – 19% for participants poststroke and 8 – 18% for the control group. The discrepancy between the two studies may be explained by the inclusion in our study of multiple variables to define tolerance. In the current study, if intolerance was defined *solely* as a drop of systolic blood pressure greater than or equal to 20 mmHg, and not by the addition of other factors such as diastolic blood pressure or heart rate, the incidence of intolerance would have been 22.2% rather than 47%.

Korpelainen et al.²¹ examined the response to a tilt table intervention in patients who were 2 – 10 days poststroke. This group found no significant difference in peripheral blood pressure readings after standing at 90 degrees for 7 minutes. These researches used a “quick passive tilting” method to achieve 90 degrees of tilt within a 2-second period. The current study used a step-wise progression of tilt, which may explain the difference in findings between the two studies.

The results of the current study differ from the A Very Early Rehabilitation Trial for Stroke (AVERT) clinical trials, where participants were able to tolerate very early mobilization within the first 24 hour following a stroke.⁹ These two studies differ when comparing modes of mobilization and definition of tolerance. The AVERT trials consider mobility both sitting up in a bed and sitting up in a chair, and do not necessary require upright standing, weight bearing postures for the definition of mobility to be satisfied. In addition, the AVERT trials used a decrease of 30 mmHg or more in systolic BP as a cut off measure to terminate a particular trial. The parameters of the current study utilized a decrease of 20 mmHg or more in systolic blood pressure, as taken from the consensus statement from the American Autonomic Society and the American Academy of Neurology.²³

When physiologic tolerances were monitored, DBP falling more than 10 mmHg was the main limiting factor to progression of the STTP. A second limiting factor was SBP falling outside of the 20 mmHg parameter. For all participants, the remaining physiologic indices (RR, SpO2, RPE), subjective report, and observational indices fell within our definition of tolerance. Each clinical index was rated with equal importance, therefore if any one of the indices was found to be outside the established parameters, the STTP was terminated. It is important to note within standard clinical practice, that both subjective and objective measures are coupled with clinical judgment to assess tolerance to progressive or ongoing interventions.

Finally, the researchers expected that initiating the STTP within 24 hours of admission could be tolerated by a majority of the subjects. Of the 7 participants who received the protocol within 24 hours, only fourteen percent (N=1) of the 7 participants in this study were able to tolerate standing during the STTP when initiated within 24 hours of admission (see Figure 1). While there appeared to be some advantage to waiting until 24 hours following admission before implementing the protocol, this finding should be interpreted cautiously without further replication of results. As noted previously, time of admission does not necessarily indicate time of onset of stroke, as there can be a large time lapse from symptom onset to hospital admission.

Limitations

The limitations of this study include a small sample size and no control for level of function or severity of stroke. Due to this small sample, we did not have sufficient power to test various predictors of tolerance in addition to type of stroke and age. Additionally, a single-session protocol limited the ability to monitor changes in tolerance over time. In the current study, the duration of time on the tilt table above 60 degrees was not studied as an independent variable, but rather was a function of the maximal angle achieved. That is, tolerance was dependent on achievement of five minutes at a specified angle. In order to develop clinical guidelines for use in a tilt table intervention, maximal time tolerated at each pre-determined angle should be studied further.

CONCLUSIONS

Risks from prolonged bed rest during hospitalization have been documented to adversely affect multiple organ systems, impede functional recovery and increase the risk of mortality and morbidity. This pilot study was designed to standardize a safe and feasible clinical intervention in an effort to increase the frequency of patient mobilization into a prolonged standing position following acute onset of stroke. The preliminary data suggests that use of the STTP during physical therapy after stroke is likely to be a safe, feasible, and functionally relevant approach to initiate early mobilization for medically fragile patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Table 1

Highest Angle Achieved

Highest angle achieved	N (%)
Unable to achieve lowest angle	10 (28)
45 degrees	7 (19)
60 degrees	4 (11)
70 degrees	8 (22)
80 degrees	1 (3)
90 degrees	6 (17)

Table 2

Percentage of Tolerance across Clinical and Subjective Indices

Tolerance Parameter	45 degrees (n = 36)*	60 degrees (n = 26)*	70 degrees (n = 19)*	80 degrees (n = 16)*	90 degrees (n = 7)*
Systolic blood pressure ¹	86	92	84	87	100
Diastolic blood pressure ²	89	88	89	72	83
Heart rate ³	97	96	100.0	100	100
Oxygen saturation ⁴	100	100	100	100	100
Dyspnea ⁵	100	100	100	100	100
Pallor ⁵	100	100	100	100	100
Perceived effort ⁶	100	100	100	100	100
Pain ⁷	100	100	100	100	100
Angina ⁸	100	100	100	100	100
Dizziness ⁸	100	96	100	93	100
Nausea ⁸	97	100	100	100	100
No Request to be lowered ⁸	100	96	100	96	96

¹No change from baseline greater than +/- 20 mmHg

²No change from baseline greater than +/- 10 mmHg

³No change from baseline greater +/- 10 beats per minute

⁴Maintained at 90%

⁵Not observed

⁶Rating of 1-5

⁷Rating of 1-5

⁸Self-reported