Impact of Prophylactic Thoracolumbosacral Orthosis Bracing on Functional Activities and Activities of Daily Living in the Pediatric Spinal Cord Injury Population

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Received November 21, 2006; accepted May 9, 2007

Abstract

Background/Objective: The purpose of this study is to assess the impact of a thoracolumbosacral orthosis (TLSO) on children with spinal cord injuries (SCI) in terms of functional independence and time requirements for performance of functional activities and to ascertain the children's preference for TLSO use.

Methods: Fourteen subjects with thoracic SCI, ages 6 to 14 years, were studied. All subjects had previously been prescribed and were using a TLSO to prevent the progression of scoliosis. Functional activities included in the Functional Independence Measure and 6 additional wheelchair and transfer skills were scored by level of assistance required. The timed motor test (TMT) included 6 activities involving dressing, transfers, and wheelchair propulsion. Subjects completed the activities of the functional activities scale (FAS) and TMT while wearing a TLSO and without a TLSO. Subjects were asked their preference for wearing or not wearing the TLSO during each of the activities.

Results: For the TMT, subjects were slower with a TLSO when donning a shirt or pants, with even and uneven transfers and hallway propulsion ($P < 0.05$). The majority of subjects preferred not wearing the TLSO during the TMT activities. Lower functional activity scores were recorded while wearing a TLSO for upper-extremity dressing ($P < 0.05$), lower-extremity dressing, bladder management, transferring to bed, and reaching for objects on the floor. Subjects preferred not wearing a TLSO for the following activities: lower-extremity dressing, bladder management, reaching for an object on the floor, and transfer from a supine to a sitting position.

Conclusions: Wearing a TLSO adversely affected independence level and time requirements for selected functional activities. Subjects preferred not wearing a TLSO while performing the activities. Activities that required hip flexion, such as donning pants or transitioning from a supine to a sitting position were restricted by the TLSO. Future studies with larger sample sizes should explore the relationships between functioning with a TLSO as related to a patient's age, level of injury, and TLSO design.

J Spinal Cord Med. 2007;30:S178–S183

Key Words: Spinal cord injuries; Scoliosis; Child; Adolescence; Bracing; Paraplegia; Tetraplegia; Activities of daily living; Orthosis

INTRODUCTION

Each year an estimated 11,000 individuals suffer a spinal cord injury (SCI). It has been suggested that 3 to 5% of SCIs occur in children younger than 15 years old and that 20% are younger than 20 years old (1–3). Age of injury is

important because the rehabilitation from both a medical and psychosocial perspective must take into account the growth of the child (4). Two orthopedic sequelae associated with injuries before skeletal maturity are the development of hip subluxation/dislocation and scoliosis (5,6). Looking at the prevalence of hip subluxation, McCarthy et al (7) examined the records of 62 children with an SCI. Of records reviewed, 93% of those injured at up to age 10 years were diagnosed with a hip subluxation/dislocation. In those injured after the age of

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Table 1. Demographics of Subjects

Subjects No.	Gender	Age (y)	Level of Injury	Cobb Angle (Degrees)	Months Wearing TLSO
1	Female	8	T4	33	24
2	Male	14	T10	47	36
3	Female	8	T4	4	15
4	Female	8	T11	5	24
5	Male	11	T1	8	120
6	Male	11	T8	50	24
7	Female	12	T7	50	108
8	Male	14	C7	19	36
9	Female	9	T12	40	16
10	Female	11	T11	36	2
11	Male	9	T8	26	12
12	Male	15	T11	16	6
13	Male	12	T6	30	36
14	Female	9	T7	5	4

TLSO = thoracolumbosacral orthosis.

10 years, only 9% were found to have a hip subluxation/dislocation. Looking at scoliosis in children with SCI, Betz and Mulcahey (4) found a similar age-dependent relationship. For patients injured before skeletal maturity, 98% developed a scoliosis. Furthermore, 67% were at risk of requiring a spinal fusion. Conversely, when injured after the age of skeletal maturity, only 20% of patients were diagnosed with scoliosis. Of those, only 5% were at risk for requiring a fusion (8–12).

Often, hip dysfunctions and scoliosis occur simultaneously in children with an SCI. Although it has been suggested that maintaining hip abduction in sitting and when supine may prevent a hip subluxation, it has not been sufficiently studied (13). On the other hand, there are several studies suggesting that a TLSO may either prevent or reduce the rate of progression of scoliosis. In a retrospective chart review, Mehta et al (14) found that prescribing a TLSO for curves of less than 20 degrees delayed the rate of progression. Furthermore, bracing curves of less than 10 degrees may prevent the need for surgery altogether. Several other studies have had similar results in SCI and other neuromuscular populations, suggesting that a TLSO should be prescribed in patients injured before maturity (9, 16–18).

The wearing of a TLSO may encourage normal orthopedic development, but the benefits on a children's function are debatable. It has been suggested that a stabilized spine (either by a TLSO or a spine fusion) will level the patients pelvis for even sitting pressures and increase balance in sitting to allow for bilateral upper-extremity activity (18–23).

What remains unclear is whether the benefits translate into an increased ease of functional activity. The benefits of a TLSO were not supported by a study of the time taken to complete a battery of functional tasks,

referred to as the timed motor test (TMT; 24). In this study, standardized FA were completed with and without a TLSO. In this pilot work, subjects wearing a TLSO were slower when donning a shirt or pants, transferring, and propelling a wheelchair.

What the TMT fails to measure is the impact of a TLSO on FA in the home setting. For example, the TMT used a standard mat table for transfers. Most patients do not transfer onto a mat table in their home, but rather onto a bed. The purpose of this study is to continue to examine the impact of a TLSO on the TMT and also to quantify its impact in the home setting using the FAS.

METHODS

Demographics

This study was designed as a cross-sectional case-control with subjects serving as their own controls. The convenience sample consisted of 14 patients, who were either admitted for an inpatient stay or could return for multiple outpatient appointments for data collection. To be included in the study, patients had to be between ages 6 and 16 years with a spinal injury between C7 and L2. The average age of the subjects was 10.8 ± 2.4 years old, with 7 boys and 7 girls. All patients had previously been prescribed a TLSO, with an average curve of 26.4 ± 17.1 degrees (range 0–50°; Table 1). On average, patients had been wearing a brace for 33 ± 36 months (2–120 months).

Timed Motor Tests

The protocol previously described for the TMT was followed (24). Essentially, the TMT is a total of 6 activities repeated a minimum of 5 times. The activities included donning a shirt, donning pants, even transfers, 4-inch uneven transfers, propelling a wheelchair on a level

Table 2. Scores and Difference of Scores of FAS When Subjects Performed the Activities With or Without a TLSO

Activity	No TLSO	With TLSO	P-value*
Eating	7	7	NS
Grooming	5.3	5.3	NS
Upper-body dressing	6.3	4.9	<0.01
Lower-body dressing	3.4	2.4	0.09
Bladder management	4.6	4.3	0.33
Bed transfers	5.6	5.1	0.167
Wheelchair propulsion	6.2	6.2	NS
Curb management	4.3	4.3	NS
Reaching for floor	7	6.6	0.34
Wheelie	6.6	6.6	NS
Holding wheelie	4.7	4.5	NS
Supine to sit	7	6.8	0.34
Sit to supine	7	7	NS

FAS = functional activity scale.

*Not significant.

surface, and propelling a wheelchair up a ramp. Activities were considered completed when subjects were able to perform the activity both with and without the TLSO. As previously described, to increase reliability of the measures, the fastest 3 times (of the 5) were used for comparing the 2 conditions (with and without a TLSO; 24). Due to unavailability of TLSOs, it was not possible to randomize the test conditions. When possible, an alternating pattern of testing with and without a TLSO was used in an attempt to have an equal number of subjects start with the different test conditions. All but 2 subjects were tested on separate days. The 2 subjects tested on the same day were given a 2- to 3-hour rest period. After completion of the second test of the 2 conditions, subjects were asked whether they preferred to perform the activity while wearing a TLSO, without the TLSO, or had no preference.

Functional Activities Scale (FAS)

The FA scale lists the activities that are typically performed by children and may be impacted, positively or negatively, by the use of a TLSO. The activities were derived from the consensus of 3 physical therapists, 2 occupational therapists, 3 physicians, and a psychologist. Activities were determined from clinical experience coupled with commonly used functional measures such as the Functional Independence Measure (FIM), Pediatric Outcomes Data Collection Instrument, and Barthel. For example, questions regarding bowel management and bathing were not included in the measure, since neither is typically carried out while wearing a TLSO. In total, a list of 13 activities was included in this FAS (Table 2). Each activity was scored by the subject's level of independence while completing the activity. The scaling is similar to the FIM: for a score of 1, the subject requires 76–100% assistance; 2, subject requires 51–75% assistance; 3, subject requires 26–50% assistance; 4, subject requires 0–25% assistance;

5, subject only requires set up; 6, subject is independent doing the activity but requires assistive equipment; and 7, subject is independent doing the activity. If a subject completed an activity at 2 different locations (ie, at home and in school), the lower score was used for the activity. Subjects were scored based upon typically occurring daily activities (rather than their maximal level of independence). For example, a subject may be able to don pants, but because of time involved, the caregiver may assist or perform the activity for the child. In this case, the subject was scored as requiring assistance. Finally, subjects were asked if they preferred to complete activities with a TLSO or without.

Statistics

Comparisons of times used analysis of variance for repeated measures utilizing a “normalized-rank” transformation to correct nonnormality of the data. Categorical variables were compared using the Fisher exact test. Preferences were compared using the chi-square test for equal proportions.

RESULTS

For each of the activities of the TMT, subjects were slower when wearing the TLSO. Donning a shirt without a TLSO took an average of 13.6 ± 4.3 seconds, but with a TLSO it took an average of 17.1 ± 8.0 seconds, a 26% increase in time (Table 3). Similarly, for donning pants, there was a 21% increase in time from 40.0 ± 8.6 seconds to 48.2 ± 12.8 seconds when wearing a TLSO. For transfers, even and uneven, the total increase in time was approximately 2 seconds, but in total, it increased the time to complete by nearly 42% for even transfers and 28% for uneven transfers (5.5 ± 3.9 seconds to 7.8 ± 4.2 seconds, and 6.4 ± 3.9 second to 8.2 ± 5.0 seconds, respectively). Wheelchair propulsion down a hallway was significantly slower, but only increased the time by a clinically

Table 3. Measured Times During Timed Motor Test for Wearing or Not Wearing a TLSO

Activity	TLSO Mean Time Seconds*	No TLSO Mean Time seconds	F-Value	P –value	Preference for TLSO Use
Donning shirt	17.1 (26%)	13.6	16.18	< 0.001	No TLSO†
Donning pants‡	48.2 (21%)	40.0	12.35	< 0.001	No TLSO†
Even transfers	7.8 (42%)	5.5	33.26	< 0.001	No TLSO†
Uneven transfers	8.2 (28%)	6.4	29.45	< 0.001	NS§
Propelling down hallway	12.7 (6%)	12.0	13.83	< 0.001	NS§
Propelling up a ramp	12.1 (4%)	11.6	2.65	0.11	NS§

*Percent of increased time due to wearing the TLSO.

†Statistically different, $P < 0.01$.

‡9 subjects included: 1 refused, 1 insufficient time, 3 unable to complete with TLSO.

§Not significant.

||3 subjects unable to complete due to fatigue or time constraints.

insignificant amount of 6% of the total time. Lastly, wheelchair propulsion ascending a ramp was not significantly impacted by wearing a TLSO.

On the FAS, wearing a TLSO did not impact the activities of eating, grooming, wheelchair propulsion, curb management, “popping wheelies,” or transitioning from sitting at the edge of a bed to a supine position (Table 2). None of the scores on the FAS increased when a subject wore a TLSO. A reduction of scores was evident for dressing (upper and lower body), bladder management, bed transfers, reaching for the floor, and transitioning from a supine position to sitting at the edge of the bed. Of those activities, only upper-body dressing was statistically significantly different, with the activity scored lower when the subject was wearing a TLSO. Scores for lower-extremity dressing were not significantly different, but approached significance with $P = 0.09$ (Table 2).

Lastly, preference for wearing a TLSO during FA activities was examined. For eating, grooming, wheelchair propulsion, and popping a wheelie, subjects did not have a preference to wear or not wear a TLSO. Preference for not wearing a TLSO was significantly different ($P < 0.05$) for lower-body dressing, reaching for the floor, and transitioning from a supine position to sitting at the edge of the bed. Nearing statistical significance was bladder management at $P = 0.071$ (Table 4).

DISCUSSION

This study attempted to systematically quantify the daily impact of a TLSO on functional activities in children with SCI. In the past, it has been hypothesized that a TLSO promotes stability during bimanual activities, particularly for children with higher-level injuries. For children with lower-level injuries who have trunk control, use of a TLSO may not aid in the activity but may interfere with

Table 4. Number and Percent of Patients That Reported Preference for Performing Functional Activities With or Without a TLSO*

	With (%)	No Difference (%)	Without (%)	P-value
Eating	1 (7)	12 (86)	1 (7)	<0.001
Grooming	1 (8)	9 (69)	3 (23)	0.018
Upper-body dressing	0 (0)	4 (29)	10 (71)	0.10
Lower-body dressing	1 (7)	3 (21)	10 (71)	<0.01
Bladder management	1 (7)	5 (36)	8 (57)	0.071
Bed transfers	1 (7)	7 (50)	6 (43)	0.110
Wheelchair propulsion	1 (8)	9 (69)	3 (23)	<0.05
Curb management	1 (25)	2 (50)	1 (25)	0.778
Reaching for floor	1 (7)	0 (0)	13 (93)	<0.01
Wheelie	3 (21)	9 (64)	2 (14)	<.05
Holding wheelie	2 (29)	4 (57)	1 (14)	0.367
Supine to sit	1 (7)	3 (21)	10 (71)	<0.01
Sit to supine	3 (21)	6 (43)	5 (36)	0.61

*Percentage may not add up to 100% due to rounding. Also, patients who did not perform the activity were excluded.

activities that require leaning forward. Furthermore, for children with lower-level injuries, being sensate in the lower trunk or extremities may make the TLSO uncomfortable to wear during activities.

Similar to the previously published data of the TMT, subjects were slower when wearing a TLSO while performing dressing, transfers, and wheelchair propulsion. A greater preference was demonstrated for not wearing a TLSO during the standardized test conditions. Furthermore, completion of dressing and transfer activities required 25% more time with the TLSO donned. The increased time is most likely reflected in the preference for not wearing a TLSO during the activity. Although not studied in SCI, clinical experience suggests that children often are resistant to wearing a TLSO and compliance is low. It may not be the loss of independence, but rather the increased “hassle factor” of wearing a TLSO that determines brace compliance. The results of this study support the development of outcome measures that do not look strictly at level of independence when quantifying the impact of a brace on a child’s life.

Regarding the impact of a TLSO in the home environment, using the FAS, subjects scored themselves as more independent without a TLSO for most activities. Only the activity of upper-body dressing was statistically different. It is likely that loss of independence was not because the TLSO interfered with upper-body dressing, but rather the subjects required help donning the TLSO. The TLSO used in this study was created by the in-hospital orthotist. As a standard, the straps are in the back of the brace, making it nearly impossible to don the brace independently. It is possible that modifying the brace may increase independence for this one activity. As for the remaining activities on the FAS, none were significantly different, but it is worth noting that the trend for nearly half of the activities was toward more independence without a TLSO.

With the FAS, similar to the TMT, it is possible that wearing a TLSO may not significantly reduce a patient’s ability to complete a task, but rather simply makes the task more difficult. It may be more useful to compare the subject’s preference for wearing or not wearing a TLSO during the week that the functional activities were performed. Statistical significance was found for preferring not to wear a TLSO for 3 activities (lower-body dressing, reaching for floor, supine to sitting position), and one activity approached significance (bladder management). As might be expected and previously reported, activities that required the most hip or trunk flexion were most likely to be impacted by a TLSO. Conversely, activities that did not involve flexibility, such as eating, grooming, and wheelchair propulsion, were not identified as problematic for subjects.

The results from the FAS must be taken with some caution, since it is well established that self-reporting may not accurately depict what actually occurs. This could affect self-report scores and the subjects’ preference for wearing a TLSO during an activity. If subjects dislike

wearing a TLSO, they may report lower scores, even if the activity is not truly impacted by the TLSO. Although the FAS includes similar activities and scoring as the FIM, the 2 measures are not equivalent. Due to the modification to the FIM to create this scale, reliability and validity previously completed on the FIM are not applicable to the FAS. To further substantiate the results of this study, reliability and validity of the FAS should be conducted. Lastly, it should be noted that this study used a convenience sample of subjects who agreed to be tested when a tester was available. This may have introduced a selection bias, attracting patients who were dissatisfied with their TLSO and wanting to “prove” its negative impact on function.

Some of the results from this study are in agreement with Muller et al (19), who studied TLSO and level of independence in patients with myelodysplasia. In that study, the authors concluded that “brace treatment of scoliosis . . . is possible to accomplish without any harmful effect on the functional and motor abilities of children.” Our current study takes their results a step further by examining preference for wearing a brace. Several of the tasks themselves, both on the FAS and TMT, were perceived as negatively affecting completion of the tasks. For children whose difficulty in daily care is amplified by a SCI, a TLSO may further complicate a task. Dislike towards wearing a TLSO could negatively affect compliance. Often parents, who recognize the importance of wearing a TLSO, will have to argue or bargain with their child to “force” brace compliance. Future studies may want to investigate the parenting styles and/or the parent-child relationship for maximizing TLSO use.

The increased preference for not wearing a TLSO may be from variables not under investigation in this study. Previous work in patients with a neuromuscular condition demonstrated decreased pulmonary function when wearing a TLSO (25). Similar results have been found in non-SCI patients with idiopathic scoliosis (26,27). In addition, the psychological impact of wearing a TLSO should not be underestimated. Fallstrom et al (28) found that patients with idiopathic scoliosis who wore a brace had a higher incidence of “disturbed body image” compared with those who underwent a spinal fusion. Clayson et al (29), comparing brace wearers with those who had spinal fusions, found lower self-esteem and freedom from body image disturbances in TLSO users. Since patients with SCI already have a more visible disability, it is possible that the psychological problems of wearing a TLSO are not analogous to those experienced by the non-SCI population with idiopathic scoliosis. This is an area currently being investigated with the newly developed Shriners Pediatric Instrument for Neuromuscular Scoliosis (SPINS) questionnaire (30).

CONCLUSIONS

Overall, subjects remained independent for most FA while wearing a TLSO. The level of independence did not reflect

the increased “hassle factor” measured in time and dissatisfaction with wearing a TLSO while performing the activity. Future studies should be conducted with a diverse population to determine if there is a subpopulation that functionally benefits from a TLSO. For example, a person with a high-cervical-level injury may benefit from the stability provided by a TLSO. Compliance of TLSO use should also be included in future studies to determine its relationship with brace satisfaction in children and parent-child relationships. Lastly, investigation is warranted in the design of the TLSO that allows for more hip flexion or the straps to be moved to the front of the brace.

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