Effect of two-speed manual wheelchair wheel on shoulder pain in wheelchair users

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INTRODUCTION

➢Manual wheelchair users (MWCU) depend on their upper extremities for mobility, transfers, pressure relief and a variety of other daily functional activities.
➢Dependence on limbs not designed for heavy repetitive loading predisposes manual wheelchair users to debilitating upper extremity problems .
➢Up to 80% of today's manual wheelchair users suffer from shoulder pain[1].
➢The purpose of this study is to investigate the impact of a new manual 2-speed wheelchair wheel (***MAGIC****WHEELS*™ , Seattle, WA, Figure 1) on shoulder pain in manual wheelchair users .

METHODS

➢ Participants: 17 MWCU with shoulder pain (WUSPI score >10)
- Age: 46.0±14.0 years
- Duration WC use: 15.1±10.1 years
- Gender: Male=9 ; Female =8
- Disabilities: spina bifida(1) ;SCI (11); post-polio(1);stroke (1);ataxia (1);Rheumatoid arthritis(1);spinal stenosis(1)

- Phase I (baseline): one month using personal wheelchair wheels
- Phase II: five months with the ***MAGIC****WHEELS*™- 2-speed wheels attached to personal wheelchair
- Phase III (retention): one month in personal wheelchair with personal wheels

Figure 1: Subject using *MAGICWHEELS*™ 2-speed wheels

➢Outcome Measures:
- Repeated Wheelchair Users Shoulder Pain Index (WUSPI) surveys[2,3] weekly during each Phase
- Pre-post Wheelchair Users Functional Assessment tests (WUFA)[4]
- Timed hill climbing using PW and 2-speed wheels with reported Relative Perceived Exertion (RPE)

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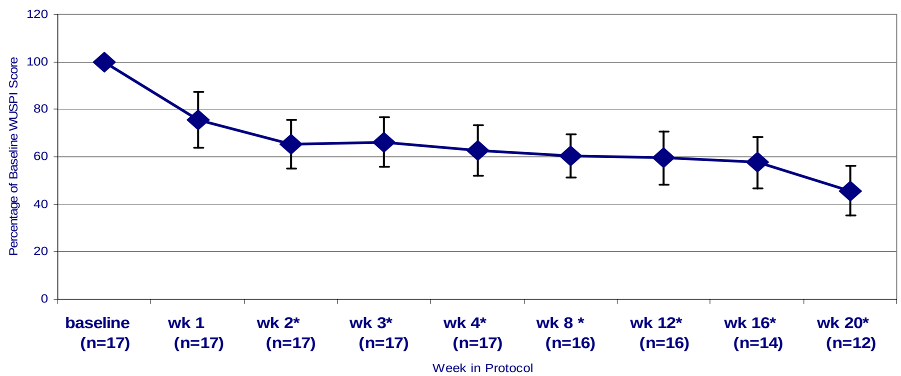
RESULTS

➢Phase I (baseline): Repeated WUSPI indicated stability in shoulder pain without application of an intervention (p=0.40).

➢Phase II: Significant reduction (percentage of baseline) in shoulder pain with the 2-gear wheel intervention was found at week 2 (p= 0.004) and continued at every week through week 16 (p=0.015) (Figure 2)

Figure 2: WUSPI Percentage Change from baseline



* = significant change from baseline

➢No difference in WUFA scores following the five month use of the ***MAGIC****WHEELS*™ 2-geared wheelchair wheel, however, there was a strong trend noted towards an improvement in function. (pre= 79.2 ±0.41, post= 80.7 ± 0.55 p=0.06).

➢Hill test using ***MAGIC****WHEELS*™ 2-speed wheels in a 2:1 gear ratio resulted in an 36% increased time (p=0.01) without a change in RPE (p =0.34).

➢Phase III (retention): Showed that the reduction in shoulder pain continued during the four weeks, the trend was for an increase in shoulder pain, returning towards the initial baseline.

➢These findings indicate the potential for shoulder pain reduction due to reduced joint loading with the use of *MAGIC*WHEELS™ 2-speed wheels during daily mobility.

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ORIGINAL ARTICLE

Effect of 2-Speed Geared Manual Wheelchair Propulsion on Shoulder Pain and Function

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ABSTRACT. Finley MA, Rodgers MM. Effect of 2-speed geared manual wheelchair propulsion on shoulder pain and function. Arch Phys Med Rehabil 2007;88:1622-7.

Objective: To investigate the impact of a manual 2-gear drive wheelchair wheel (MAGICWheels) on shoulder pain and function in manual wheelchair users.

Design: A single-group, repeated-measures pre- and post-design with baseline and retention.

Setting: General community.

Participants: Full-time manual wheelchair users (N=17) currently experiencing shoulder pain (mean age, 46±14y; wheelchair use, 15±10y).

Intervention: Five-month trial using a 2-gear wheelchair wheel.

Main Outcomes Measures: The Wheelchair Users Shoulder Pain Index (WUSPI), Wheelchair Users Functional Assessment (WUFA), and timed hill climb test with rating of perceived exertion (RPE).

Results: There was significant reduction in shoulder pain after the intervention at week 2 (P=.004) through week 16 (P=.015). The difference was not found at week 20; however, 1 participant reported an increase in pain from unrelated factors during week 20. Change from baseline was calculated without this subject's data; there was a significant reduction in shoulder pain (P=.003). There was no difference in WUFA after using the 2-gear wheel (P=.06). Hill climb time was longer when using the 2-gear wheel (P=.01), but no difference in the RPE (P=.13) resulted. Shoulder pain during the 4-week retention phase showed a trend toward increasing, as indicated by increased WUSPI scores. There was not a significant percentage increase, however, in comparison with the final week of using the MAGICWheels (P<.05).

Conclusions: There were pain reductions 2 weeks after using the MAGICWheels, indicating a rapid response to the intervention. These findings indicate the potential for shoulder pain reduction with the use of a manual drive wheel during mobility, even in highly functional manual wheelchair users.

Key Words: Rehabilitation; Shoulder pain; Wheelchairs.

THE NATIONAL INSTITUTE on Disability and Rehabilitation Research[1] reported in 2000 that nearly 1.7 million people in the United Sates have disabilities that require the use of a wheelchair, with 1.5 million using a manual chair. Manual wheelchair users are included within the disability groups of spinal cord injury, lower-limb amputation, stroke, multiple sclerosis, rheumatoid arthritis, spina bifida, poliomyelitis, and hip fracture, as well as in other groups.

Manual wheelchair users use their upper extremities for mobility, transfers, pressure relief, and several other daily functional activities. Their dependence on limbs not designed for heavy repetitive loading predisposes them to debilitating upper-extremity problems. Possible causes or correlations to the development of shoulder pathologies include time since injury,[2,3] the repetitive nature of wheelchair propulsion,[4,5] the strong strength of the shoulder muscles required for wheelchair propulsion,[6] loading of the joints at extremes of motion,[2,6,7] and muscular weakness or imbalance.[4,8,9] Others[6,10] have concluded that in conjunction with high internal joint forces, the abnormal stresses applied to the subacromial area during wheelchair propulsion and transfer contribute to the high rate of shoulder problems in patients with paraplegia.

The prevalence of shoulder pain is high is this population, with as many as 75% of manual wheelchair users reporting a history of pain.[11] Early onset of shoulder pain after injury is predictive of persistent pain long after injury.[8] Previous researchers have explored the incidence of shoulder pain, specific pathologies, and the history of occurrence. Of the 52 manual wheelchair users, 15 (26%) reported current shoulder pain, while 33 (60%) reported at least 1 episode of shoulder pain in the past.[12] Manual wheelchair users with shoulder pain reported pain levels 4 times greater during level and incline propulsion than did their asymptomatic counterparts.[13,14]

The ergonomics literature has provided some insight into the stress-strain and repetitive nature of wheelchair propulsion and overuse injuries. Silverstein et al[15] classified a highly repetitive task as having 1 cycle every 30 seconds and low to high force loads ranging from 9.8 to 39N. Loslever and Ranaivosoa[16] reported that the time spent with forces over 20N caused damage. It has been shown that the cycle frequency of wheelchair propulsion is much higher (<1s) and forces are in the range of those reported by Silverstein, with compressive forces greater than 20N occurring in nearly 60% of the propulsion cycle.[17]

Battery-powered assistive wheels have reduced joint angles as well as oxygen consumption.[18] The manual wheelchair users who participated in previous studies, however, were without shoulder pain and gave these devices poor ratings on such activities of daily living (ADLs) as transfers to cars because of the significant increase in weight (up to 22.5kg [50lb]) added by the wheels.[18] The ability to reduce the required force production to navigate terrain during propulsion, without additional demands imposed by the prohibitive added weight often found in other devices, may benefit manual wheelchair users who have shoulder pain. MAGICWheels,[a] a manual shifting, 2-geared wheelchair wheel used in the 2:1 gear ratio, decreases upper-extremity stresses by reducing the force needed to propel

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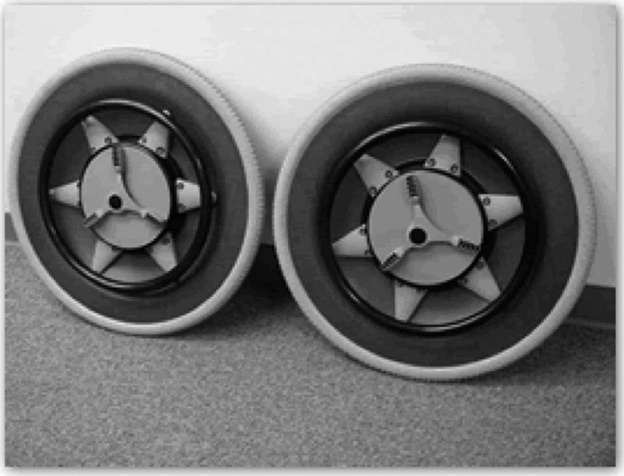

Fig 1. MAGICWheels 2-geared wheelchair wheel. NOTE. The 2-geared wheels used by the participants for a 5-month phase.

on a surface. The MAGICwheels' hill hold and brake assist further reduces demands when climbing a hill by eliminating the additional strokes resulting from rolling backward. (fig 1). Reducing the demands on the shoulder joint during performance of primary daily activities, specifically wheelchair propulsion, may result in an overall reduction in shoulder pain and ultimately improve the performance of numerous vital ADLs. Therefore, our purpose in this study was to determine the impact on shoulder pain and function in manual wheelchair users of the new MAGICWheels. We hypothesized that: (1) shoulder pain in manual wheelchair users would be reduced; (2) functional performance would be improved; and (3) incline navigation would be improved, with a reduced time for ascent and reduced subjective rating of difficulty.

METHODS

We enrolled a convenience sample of 17 full-time manual wheelchair users with shoulder pain (mean age, 46±14y; wheelchair use, 15.1±10.1y) (table 1). The study included a 4-week baseline phase with subjects using personal wheels (no intervention), a 5-month phase in which subjects used the MAGICWheels 2-gear wheel, and a 4-week retention phase in which subjects used their personal wheels. Inclusion criteria included current shoulder pain or recurrent, frequent episodes (at least monthly) of pain, defined as pain with a minimum score of 10 on the Wheelchair Users Shoulder Pain Index (WUSPI) during all 4 weeks of the baseline phase; and multiple weekly (minimum, 7) exposures to wheelchair activities in challenging environments that require navigation of hills and/or uneven terrain (once a day). Subjects were instructed to continue taking their current medications throughout the study and to report any medication changes.

The 2-gear wheelchair drive was mounted on standard push-button operated, quick-release axles that fit the axle mountings already on the user's personal wheelchair. Axle plate wheelchairs had an anti-rotation adapter applied to restrain the inner hub. The system had a 2.54cm (1in) tube tire and 1.91cm (.75in) hand rim, resulting in a 60.96cm (24in) diameter times 8.89cm (3.5in) thick (excluding axles) with a weight of 40.3N (9.1lb). Replacing standard wheels with a pair added less than 44.5N (10lb) of weight and no additional width to the participant's wheelchair.

Outcome measures were the WUSPI, Wheelchair Users Functional Assessment (WUFA), self-reported activities, and a timed hill test. To determine whether participants regularly encountered situations that would indicate use of MAGICWheels, an activities survey of their weekly propulsion environment was completed throughout the study at the WUSPI intervals. As noted previously, participants were required to encounter an environmentally challenging combination of hills, ramps, and uneven terrain once a day at a minimum of 7 times weekly. A clinical shoulder evaluation consisting of range of motion (ROM), manual muscle testing,[19] and shoulder special tests (load and shift,[20,21] sulcus,[20,21] Neer impingement,[22,23] Hawkins-Kennedy,[24] Speed test[20,21]) was performed at the initial baseline visit and at the beginning and the end of the MAGICWheels phase. The institutional review board of the University of Maryland School of Medicine approved this protocol, and each subject provided informed consent before participating.

Table 1: Subject Demographics

Age (y)	Sex	Disability	Wheelchair Use (y)	
33	Male	Spina bifida	15	
40	Male	SCI T11-12	17	
65	Female	Postpolio syndrome	15	
51	Female	SCI (thoracic)	31	
42	Male	SCI T4-5	25	
62	Male	Stroke	19	
54	Male	SCI T4-5	10	
37	Female	Spinal stenosis	7	
66	Female	Rheumatoid arthritis	5	
39	Male	SCI L1-2	3	
27	Female	SCI T6	6	
22	Female	SCI C6-7	5	
37	Male	SCI T2	8	
Noncompleters				Reason for Withdrawal
65	Female	SCI T10-11	22	Transportation
34	Male	Ataxia	6	Wheels
61	Male	SCI T10	36	MVC injuries
40	Female	SCI T12	26	Personal reasons

Abbreviations: MVC, motor vehicle collision; SCI, spinal cord injury.

Wheelchair User's Shoulder Pain Index

The WUSPI is a 15-item self-report instrument that detects the effect of shoulder pain on the performance of daily activities.[25] The items are: (1) transfer from bed to wheelchair, (2) transfer from wheelchair to car, (3) transfer from wheelchair to tub or shower, (4) loading the wheelchair into a car, (5) pushing the wheelchair for 10 minutes or more, (6) pushing up ramps or outdoor inclines, (7) lifting objects to remove them from an overhead shelf, (8) putting on pants, (9) putting on a T-shirt or pullover, (10) putting on a button down shirt, (11) washing one's back, (12) usual daily activities at work or school, (13) driving, (14) performing household chores; and (15) sleeping. The instrument is based on visual analog scales, with a minimum score of 0 (no pain) and a maximum score of 10cm (worst pain ever experienced) for each of the 15 items. The total score is calculated by summing all 15-item scores resulting in a possible range of 0 to 150cm. The performance-adjusted WUSPI score is calculated by dividing the total score by the number of completed items. The WUSPI has shown high reliability and internal consistency.[25]

To determine stability of shoulder pain before the intervention, subjects completed WUSPI surveys at enrollment and then for 4 consecutive weeks during the baseline phase (5 surveys total). During the use of the MAGICWheels, subjects completed the WUSPI survey weekly in the initial 4 weeks, then monthly for the remainder of the phase, for a total of 8 surveys completed during the intervention. Weekly WUSPI surveys were completed during the 4-week retention phase.

Wheelchair Users Functional Assessment

The WUFA[26] consists of 13 basic and community activities: (1) tightspace, (2) uneven terrain, (3) door management, (4) street crossing, (5) ramp, (6) curb, (7) bed, (8) transfer, (9) toilet transfer, (10) floor transfer, (11) bathing, (12) upper and lower dressing, and (13) reaching function, picking up objects, and sweeping. Each item is timed with a maximum score of 7. To receive a score of 7, a person must complete each activity before the cutoff time without assistance. In addition, the amount of assistance required and the need for assistive devices are considered when each item is scored. All scores are then summed to obtain a total score. The highest and lowest scores possible are 91 and 13, respectively. The WUFA has good content validity, interrater reliability and stability, and good internal consistency.[26] Participants completed the WUFA at initial enrollment and after the 5-month phase in which the MAGICWheels were used.

Activities Log

The activity log survey required the participant to report the number of times a week they encountered hills, ramps and/or inclines, carpet, gravel, curbs, and grass surfaces. These are the physical environments in which the MAGICWheels' 2-geared wheelchair system maximally assists the user. To determine stability of activity levels and to verify that inclusion criteria were met prior to the intervention, 4 weekly activity surveys were completed during the baseline phase. To verify the continuation of the level of activity at enrollment, as well as to determine whether they increased their activity when using the MAGICWheels, subjects completed the activity surveys weekly for the initial 4 weeks and then monthly for the remainder of the phase for a total of 8 surveys completed during the intervention. Weekly activity surveys were also completed during the 4-week retention phase.

Incline Test

The incline test consisted of wheelchair navigation up an incline of 20m, 20° incline (1:2.5 incline) using their personal wheelchairs and the MAGICWheels in 2:1 gearing. The Americans with Disabilities Act of 1990[27] requires that ramps not exceed 1:12 (1in rise for every 12in of run). The incline, located in a parking garage, was selected to be especially challenging to the manual wheelchair users so that the gearing features of MAGICWheels would be emphasized. Variables measured during the incline tests were: (1) total time (in seconds) from starting point to crossing the end of the 20-m incline and (2) subjective rating of difficulty with the Borg Rate of Perceived Exertion (RPE) scale.[28] The incline testing was performed before and after the use of MAGICWheels.

Data Analysis

Repeated-measures analysis of variance (ANOVA) determined the stability of shoulder pain and activity level during baseline phase. Because there was no change in shoulder pain or activity level without an intervention, we calculated the mean of the 5 baseline scores and defined it as the baseline WUSPI score and baseline activity level. The percentage change in total WUSPI score was calculated (baseline score-current score / baseline score × 100) and compared with the baseline score, using repeated-measures ANOVA at weeks 1 through 4 of MAGICWheels' use (n=17), and weeks 8 (n=16), 12 (n=16), 16 (n=14), and 20 (n=12). Differences in the pre- and post-MAGICWheels phase WUFA, activity levels, and clinical evaluation variables were determined using repeated-measures ANOVA. We analyzed the incline variables with a 2-way (wheel type and test) repeated-measures ANOVA. To control for family-wise error, significant findings were further analyzed with a Tukey post hoc test.[29] An α level of .05 was used in all statistical analyses.

RESULTS

Clinical Evaluation

Aside from using the 2-geared wheelchair wheel, none of the participants received additional therapeutic interventions, nor had changes in their analgesic or anti-inflammatory medications during the study. There were no differences in shoulder ROM, upper-extremity strength, or the incidence of specific shoulder diagnoses after use of MAGICWheels ($P<.05$). The mean glenohumeral elevation was greater than or equal to 150°, external rotation was greater than or equal to 80°, and internal rotation was greater than or equal to 45°. Muscle strength was greater than or equal to 4 out of 5 for all upper-extremity muscle groups tested (rotator cuff, serratus anterior, deltoid, upper trapezius, biceps, triceps).[19] Clinical findings revealed that 2 participants had bilateral multidirectional instability and bilateral impingement signs. One participant had anterior instability. There were impingement signs in 14 of the 17 participants and were bilateral in 7 participants.

Wheelchair Users Shoulder Pain Index

Although 17 participants began using MAGICWheels on their personal wheelchairs, only 13 completed all 5 months. Reasons for withdrawal from participation were: "not liking the wheels" (n=1, before week 8), automobile collision causing other injuries (n=1, before week 16), transportation issues (n=1, before week 20), and unrelated personal issues (n=1, before week 20). The mean time of the MAGICWheels phase was 18.1±4.3 weeks for all 17 subjects, with a 91% completion rate for the designated 20 weeks.

Table 2: WUSPI Scores by Week During Baseline Phase (N=17)

Week	Mean WUSPI Performance Adjusted Score ± SD	Range of WUSPI Performance Adjusted Score
Enrollment week 0	53.9±24.3	16.4–82.5
Baseline week 1	51.4±30.6	13.5–108.0
Baseline week 2	48.9±28.7	12.8–98.9
Baseline week 3	48.7±28.2	8.4–116.4
Baseline week 4	49.5±33.8	7.2–100.6
Baseline phase	50.5±27.6	15.4–95.9

Abbreviation: SD, standard deviation.

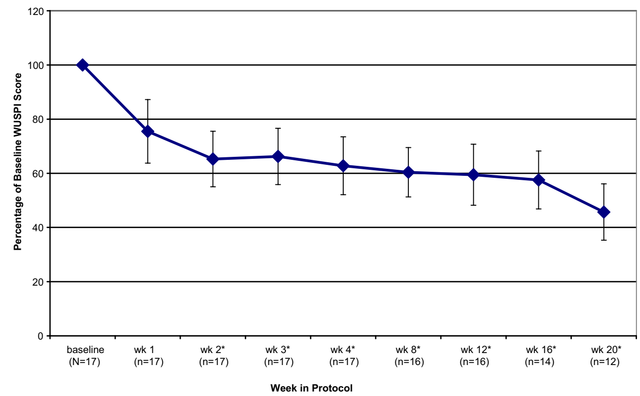

Fig 2. Reduction in shoulder pain during 2-gear wheel phase and retention phase. NOTE. The reduction in WUSPI score is compared with baseline pain level (means and standard error of mean). Baseline is expressed as 100% pain with weeks during phase illustrated as a reduction. *Significant reduction from baseline.

Shoulder pain was stable (P=.40) during the baseline phase (table 2). The mean WUSPI score for the baseline phase was 50.5±27.6. Because 4 subjects withdrew before the end of the full 20-week protocol, the data were carried forward and revealed a post-MAGICWheels phase WUSPI of 31.5±33.1. There was a significant reduction in the absolute change score (19±34, P=.035) and in the change expressed as a percentage of baseline 34.2%±64.3% (P=.044). There was a significant reduction (percentage of baseline) in shoulder pain with the MAGICWheels intervention at week 2 (P=.004) and that continued at every week through week 16 (P=.015) (table 3). The difference was not found at week 20 (P=.062), however, 1 participant reported a significant increase in pain during week 20 caused by factors unrelated to the study. This subject had experienced reduced pain throughout all previous weeks of the MAGICWheels phase. Significant reduction in shoulder pain (P=.003) resulted when the percentage change at week 20, compared with baseline, was calculated without this subject's data (−54.3%±10.4%, n=12) (fig 2). A post hoc correlation analysis determined that there was no significant relation between duration of wheelchair use and pain reduction in any week of the MAGICWheels phase. There was poor correlation among the weeks and the duration of wheelchair use (r^2 range, −.05 to 12).

Shoulder pain during the 4-week retention phase (n=12, the participant with increased pain at week 20 did not complete the retention data) showed a trend to increase, as indicated by increased WUSPI scores. There was not, however, a significant percentage increase in comparison with the final week of using the MAGICWheels (P<.05). The final WUSPI score (week 20) during the MAGICWheels phase was 26.3±7.6 and the mean of the 4-week retention phase was 37.1±7.7, which no longer showed a reduction in shoulder pain as compared with the baseline enrollment score (P=.33). There was no difference in percentage change WUSPI scores during the retention phase compared with baseline (see table 3). The mean WUSPI score during the retention phase did not differ (P=.45) from the baseline WUSPI (51.8±7.9).

Activity Level

All 6 of the self-reported activities were stable throughout the 4-week baseline (range, P=.07 [for carpet] to P=.60 [for inclines and/or ramps]). There was a significant difference in activities among the 3 phases (table 4). Increased encounters with carpeted (P<.01) and grass (P<.001) surfaces occurred during the MAGICWheels phase compared with the baseline phase. Additionally, there were increases in hill encounters (P=.009), gravel (P=.03), and grass (P=.03) surfaces during the retention phase as compared with baseline.

Wheelchair Users Functional Assessment

There was no difference in WUFA scores after the 5-month use of the MAGICWheels; however, there was a strong trend

Table 3: WUSPI Absolute Score Change and Percentage Change From Baseline, by Week

Week	n	Mean Absolute Change From Baseline ± SEM	P	Mean Percentage Change From Baseline ± SEM	P
MW week 1	17	−8.8±5.9	.154	−24.5±11.7	.053
MW week 2	17	−12.1±6.1	.063	−34.7±10.3*	.004
MW week 3	17	−10.8±5.7	.077	−33.8±10.4*	.005
MW week 4	17	−13.0±5.6*	.032	−37.2±10.7*	.003
MW week 8	16	−16.6±5.3*	.007	−39.6±9.1*	.001
MW week 12	16	−17.1±6.1*	.013	−40.5±11.3*	.003
MW week 16	14	−22.0±7.8*	.015	−42.4±10.7*	.002
MW week 20	12	−30.6±8.2*	.003	−54.3±10.4*	.003
Retention week 1	12	−15.5±8.3	.087	−20.1±13.6	.169
Retention week 2	12	−19.5±7.7*	.028	−29.2±13.4	.052
Retention week 3	12	−7.9±8.2	.352	−5.7±18.5	.763
Retention week 4	12	−17.6±9.6	.098	−24.9±18.2	.205

Abbreviations: MW, MAGICWheels 2-geared wheelchair wheel; SEM, standard error of mean.
*Significant decrease vs baseline phase mean (P≤.05).

Table 4: Activity Encounters by Phases

Phase	Mean Baseline ± SEM	n	Mean MW Phase ± SEM	n	Mean Retention Phase ± SEM	n
Inclines and/or ramps	19.6±1.3	14	19.1±1.1	14	20.7±1.9	9
Hills	5.9±1.1	12	9.0±1.0	10	11.8±1.8*	6
Carpet	5.5±1.4	8	11.5±1.2*	8	10.2±1.8	6
Gravel	9.5±1.4	11	12.5±1.5	10	17.0±2.7*	4
Curbs	6.7±0.8	9	7.5±0.8	8	7.8±1.2	6
Grass	7.8±1.5	13	14.3±1.4*	10	13.4±2.6*	5

*Significant increase vs baseline phase ($P\leq.05$).

toward improvement in function (pre, 79.2±0.41; post, 80.7±0.55; $P=.06$).

Incline Test

There was no interaction between wheel type (personal wheels vs MAGICWheels) in time required to ascend the hill or in the reported RPE. There were no differences pre- and postuse of the MAGICWheels in time required to climb or the RPE. There was a main effect ($P<.01$), however, for wheel type in the time to climb the hill with the geared wheel taking significantly longer (personal wheels, 21.3±1.7s; MAGICWheels, 35.5±1.8s). The RPE did not differ between the wheel types ($P=.13$).

DISCUSSION

Shoulder pain is a common complaint among wheelchair users.[11,12] The repetitive nature of wheelchair propulsion[4,5] along with the increased joint forces associated with pushing up hills[13,14] and performing weight relief maneuvers and transfers have been implicated in the development of pain.[2,6,7,30-32] There has been limited research into the impact of power assist wheelchairs on the reduction of shoulder pain and pathology. Our purpose in this study was to determine the impact of the MAGICWheels 2-gear drive wheelchair wheel on shoulder pain and function in manual wheelchair users. All participants were experiencing shoulder pain; the cohort's mean WUSPI score was 50.5±6.7 at the time of enrollment. We confirmed that in the absence of any interventions, their shoulder pain was stable during the 4-week baseline phase. Use of the MAGICWheels resulted in a significant reduction in that pain after only 2 weeks, independent of how long each subject had been using a wheelchair. This pain reduction continued throughout the entire 5-month phase of the trial, with the reduction averaging 38.4% from baseline. Similarly, Curtis et al[11] reported a 39.3% reduction in shoulder pain after a 6-month exercise intervention in manual wheelchair users with chronic shoulder pain, and Nawoczenski et al[33] reported a 23% reduction in shoulder pain in subjects with SCI after only 2 months of an exercise intervention. There was no reported reduction in perceived pain when our subjects used the 2-geared wheel during the hill climb, compared with the use of their personal wheels or after the 2-gear wheel phase. The amount of shoulder pain was not reported during this test, however. It is possible that the increased time required to climb the hill in the 2:1 gear ratio may have been deemed to be as challenging as the shorter time in their personal wheels, therefore they noted no change in RPE.The increased time and a suspected increased stroke cadence when using the gearing on hills potentially could have led to increased upper-extremity pain. Despite the longer amount of time needed to perform activities when using the gearing system on hills and uneven terrain, outcomes revealed an overall reduction in shoulder pain.

A concern with any power-assist wheelchair device is the additional weight of the wheels.[18] Certainly, before the study we considered the possibility that the added weight (≈44.5N [10lb]) of the MAGICWheels would lead to an increase in shoulder pain. The concern proved unfounded as the individual item analysis on the WUSPI revealed that there was no increase in pain on the weight-dependent item, "loading wheelchair into car," as reported by the 9 participants who regularly performed the task, and overall shoulder pain was reduced significantly.

Although the retention phase showed that the reduction in pain continued during the 4 weeks, the trend was for a highly variable increase in pain, returning toward the initial baseline. Withdrawal of the assistive wheels resulted in a rapid increase in pain compared with the final week of use and a return toward baseline levels. This is an indication that it was the power assist of the MAGICWheels and the subsequent reduction in shoulder joint stresses that led to the reduction in pain.

Both functional and psychosocial consequences of upper-extremity pain, dysfunction, and limited mobility are substantial.[34,35] Further physical limitations are caused by pain, and pain itself is among the primary factors that negatively affect quality of life.[34,35] In addition to the demands placed on people with disabilities and their families, the loss of productivity and the disabling comorbidity places a large burden on the health care system. In exit surveys with our participants, all reported that they were able to propel on surfaces and terrains that they had previously avoided or surfaces on which they had found difficulty in maneuvering. Although several reported they were frustrated by increased time taken to ascend a hill, most found the MAGICWheels to be advantageous. Although 4 subjects did not complete the entire 20 weeks with the device, only 1 person who withdrew from the study did so secondary to the MAGICWheels. Many reported favorable opinions about the device; however, due to financial restrictions, none opted to purchase it when the study ended. Optimizing wellness over the life span for people who use manual wheelchairs and other upper-extremity weight-bearing assistive devices is critical. The 2-gear drive wheelchair wheels may be a device that will help meet this need.

The reduction in shoulder pain did not lead to improved function as measured by the WUFA, which is a valid and reliable instrument for discriminating between high- and lower-functioning wheelchair users.[26] Because the mean baseline score was high (85% of maximum), however, the lack of improvement in functional level may have been a result of a ceiling effect. All participants were highly independent because our inclusion criteria required participants to be active in environments that included uneven terrain and frequent hills, as well as to be experiencing shoulder pain. Therefore, this may have biased our participant selection.

Study Limitations

Internal validity of this study had several potential limitations. The lack of a control group, the use of a cross-sectional sample of convenience, and the specific inclusion criteria may have led to a selection bias of more motivated participants. Because many manual wheelchair users who experience shoulder pain do not seek any interventions, involvement in the study itself (Hawthorne effect[36]) may have been the reason for the reduction of pain, rather than the specific intervention of the MAGICWheels. Although only 1 participant who withdrew reported it was because of the wheels, the attrition within the study is a potential limitation.

CONCLUSIONS

An intervention that can reduce shoulder pain and potentially promote increased mobility and independence is of utmost importance to manual wheelchair users. The MAGICWheels 2-gear drive wheelchair wheels have been shown to reduce shoulder pain with short-time use (2wk); it has the potential to result in a progressive reduction in pain with its use over a longer time. Larger randomized controlled trials to study the effect of MAGICWheels on upper-extremity pain reduction are warranted. Another investigation could examine the potential use of the MAGICWheels in preventing the onset of shoulder pain through its use in wheelchair training.

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Supplier

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