

A Digital Health Exercise Program's Effect on Intention for Spinal Surgery in Adult Spinal Deformity: Exploratory Cross-Sectional Survey

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A Digital Health Exercise Program's Effect on Intention for Spinal Surgery in Adult Spinal Deformity: Exploratory Cross-Sectional Survey

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Abstract

Background: Adult scoliosis (AS) is a prevalent condition estimated at 38%. Symptomatic AS is associated with substantial healthcare costs. The role of nonoperative interventions in the management of AS remains elusive. The National Scoliosis Clinic's (NSC) Scoliosis Realignment Therapy (SRT) is a personalized digital health exercise program for the nonoperative management of AS.

Objective: The purpose of this study was two-fold: (1) To evaluate the effect of the SRT program on users' intention of having spinal fusion; and (2) From a US payer perspective, to estimate the annual cost savings per 100,000 beneficiaries by averting spinal surgery.

Methods: Individuals were enrolled in the SRT study from October 1, 2023 to September 1, 2024. Participants were surveyed about history of prior scoliosis surgery and intent of having surgery before and after use of SRT (on a 4-point Likert scale, where 1 = "No Intent for Surgery" and 4 = "High Intent for Surgery"). Intent for surgery before and after participation in SRT was compared using a paired t-test. Annual cost savings per 100,000 beneficiaries by averting spinal fusions were estimated separately for commercial payers and Medicare using published literature and public data sources. Payer expenditures were inflation-adjusted to 2024 US dollars using the Hospital Services component of the Consumer Price Index.

Results: In total, 62 NSC members were enrolled in the SRT study for an average of 17 weeks (SD 12). The mean age was 65.3 (SD 13.5) years and the majority were female (98%) and white (98%). Among the SRT users who did not have prior scoliosis surgery (N=56), 14% (8/56) reported a decrease in intent for surgery (that is, a lower Likert score) with use of SRT. The mean intent for surgery scores before compared to after SRT were 1.29 (SD 0.53) and 1.14 (SD 0.35), respectively (mean difference 0.15 [P=.004, Cohen d=0.32]). Participants with "No Intent for Surgery" pre- versus post-use of SRT (42/56 versus 48/56, respectively) corresponds to an absolute risk reduction (ARR) of 11% and a number needed to treat (NNT) of 9 to avert one spinal fusion. Among the six participants who transitioned to "No Intent" for spinal surgery with use of SRT, three were <65 and three were ≥65 years of age. Annual cost savings from averted spinal surgeries were estimated at US \$415,000 per 100,000 commercially-insured beneficiaries and US \$617,000 per 100,000 Medicare beneficiaries.

Conclusions: SRT is a personalized, scoliosis-specific digital health exercise program with the potential for averting 1 spinal surgery for every 9 participants, resulting in a substantial reduction in payer expenditures while improving quality of care for commercial payer and Medicare beneficiaries.

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A Digital Health Exercise Program's Effect on Intention for Spinal Surgery in Adult Spinal Deformity: Exploratory Cross-Sectional Survey

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Abstract

BACKGROUND:

Adult spinal deformity (ASD) is a prevalent condition estimated at 38%. Symptomatic ASD is associated with substantial healthcare costs. The role of nonoperative interventions in the management of ASD remains elusive. The National Scoliosis Clinic's (NSC) Scoliosis Realignment Therapy (SRT) is a personalized digital health exercise program for the nonoperative management of ASD.

OBJECTIVE:

The purpose of this exploratory study was two-fold: (1) To evaluate the effect of the SRT program on users' intention of having spinal fusion; and (2) From a US payer perspective, to estimate the annual cost savings per 100,000 beneficiaries by averting spinal surgery.

METHODS:

Individuals were enrolled in the SRT study from October 1, 2023 to September 1, 2024. Participants completed a web-based, cross-sectional survey about history of prior scoliosis surgery and intent of having surgery before and after use of SRT (on a 4-point Likert scale, where 1 = "No Intent for Surgery" and 4 = "High Intent for Surgery"). Intent for surgery before and after participation in SRT was compared using a non-parametric Wilcoxon signed-rank test for paired data. Annual cost savings per 100,000 beneficiaries by averting spinal fusions were estimated separately for commercial payers and Medicare using published literature and public data sources. Payer expenditures were inflation-adjusted to 2024 US dollars using the Hospital Services component of the Consumer Price Index.

RESULTS:

A total of 62 NSC members (38.8%) responded to the survey and were enrolled in the SRT program for an average of 17 weeks (SD 12). The mean age was 65.3 (SD 13.5) years and the majority were female (98%) and white (98%). Among the SRT users who did not have prior scoliosis surgery (N=56), 14% (8/56) reported a decrease in intent for surgery (that is, a lower Likert score) with use of SRT. The mean intent for surgery scores before compared to after SRT were 1.29 (SD 0.53) and 1.14 (SD 0.35), respectively (mean difference 0.15 [$P=.006$]). Participants with "No Intent for Surgery" pre- versus post-use of SRT (42/56 versus 48/56, respectively) corresponds to an absolute risk reduction (ARR) of 11% and a number needed to treat (NNT) of 9 to avert one spinal fusion. Among the six participants who transitioned to "No Intent" for spinal surgery with use of SRT, three

were <65 and three were ≥ 65 years of age. Annual cost savings from averted spinal surgeries were estimated at US \$415,000 per 100,000 commercially-insured beneficiaries and US \$617,000 per 100,000 Medicare beneficiaries.

CONCLUSION:

SRT is a personalized, scoliosis-specific digital health exercise program with the potential for averting 1 spinal surgery for every 9 participants, resulting in a substantial reduction in payer expenditures while improving quality of care for commercial payer and Medicare beneficiaries.

KEY WORDS: Adult Spinal Deformity, Scoliosis, Nonoperative Management, Spinal Realignment Therapy, Digital Health, Program Evaluation

Introduction

Adult spinal deformity (ASD) is a common condition with an estimated prevalence of 38% for primary (*de novo*) degenerative scoliosis [1,2]. ASD is a 3-dimensional deformity of the spine defined by a major curve magnitude angle of $\geq 10^\circ$ and females are more likely to have the diagnosis [1-4]. Symptomatic ASD patients report increased back pain as well as lower health-related quality of life (HRQoL) as demonstrated by worse SF-36 scores compared to the general population [5,6].

As the nation's population continues to age there is growing interest in understanding the most effective means to manage ASD. While nonoperative modalities are typically the first-line treatment for patients with symptomatic ASD, the role of nonoperative management has been questioned with some studies reporting two-year costs ranging from \$2,041 to \$14,022 without improvements in patient outcomes [7-9]. In contrast, several studies have reported that patients who receive operative interventions for ASD have significantly reduced disability and pain and better improvement in clinical outcomes compared to nonoperative treatment [9-12]. However, spinal fusion is costly (Medicare reimbursement of \$60,269 [13]) and carries significant risk; a multicenter database study of nearly one-thousand adult ASD surgical patients with two-year follow-up reported an overall complication rate of 67.4% [14], and a separate meta-analysis demonstrated complication rates ranging from 17.0% to 71.5% [12]. Considering the substantial economic burden and complication rate associated with operative interventions for ASD – and noting that, other digital care programs in orthopedics (low back pain and chronic knee pain) have demonstrated significant reductions in surgical intent [15-17] – this study sought to further elucidate the role of a digital health program in the nonoperative management of ASD.

The National Scoliosis Clinic's Scoliosis Realignment Therapy (SRT) is a remote, exercise-based,

ScolioPilates® therapy specifically designed for individuals with scoliosis. ScolioPilates® is a scoliosis-specific exercise program utilizing elongation, corrective breathing, strengthening, and activities of daily living to address pain associated with scoliosis. Additionally, members of SRT are enrolled into a supportive community with virtual group sessions, education and AI-driven technology to assess spinal curvature with personalized therapy. Whereas Clohisy et al. reported that the majority of patients crossover from nonoperative to operative treatment due to perceived worsening of symptoms, Rhode et al. recently reported that use of SRT for six weeks resulted in significant improvement in pain as measured by the Scoliosis Research Society Health-Related Quality of Life Questionnaire (SRS-22r) [18,19].

The purpose of this exploratory study was two-fold: (1) To evaluate the effect of the SRT program on users' intention of having spinal fusion; and (2) From a US payer perspective, to estimate the annual cost savings per 100,000 beneficiaries by averting spinal surgery.

Methods

Recruitment

Individuals with scoliosis were recruited to the NSC through multiple mechanisms, including social media and the NSC website. NSC members were enrolled nationwide in the SRT study between October 1st, 2023 and September 1st, 2024. All NSC members using SRT during the aforementioned time period were invited by email to participate in the closed web-based, cross-sectional survey about surgical intention. A formal sample size calculation was not performed given that this was an exploratory study. In addition to demographics and clinical characteristics, the survey asked, “Has a surgeon ever told you you need scoliosis surgery, or offered you surgery?”, “Have you ever intended to have scoliosis surgery?” and “Since you have started working with the NSC SRT, what is your current intention to have scoliosis surgery?” Responses to the questions about surgical intent were

graded on a 4-point Likert scale, where 1 = No Intent for Surgery, 2=Low Intent, 3=Moderate Intent, and 4 = High Intent for Surgery. Given that this was an exploratory web-based survey, radiographic parameters were not collected.

Statistical Analysis

The primary outcome measure was the intent to pursue surgical correction of scoliosis pain. A non-parametric Wilcoxon signed-rank test for paired data was conducted to evaluate the difference in intention scores before and following SRT. The Wilcoxon test is appropriate for small samples that are not normally distributed. All analyses were performed using R version 4.4.1.

For potentially averted spinal surgeries, annual cost savings per 100,000 beneficiaries were estimated separately for US commercial payers and Medicare using published literature and multiple public data sources (Table 1). Payer expenditures were inflation-adjusted to 2024 US dollars using the Hospital Services component of the Consumer Price Index.

Table 1: Parameter values, data sources, and estimated cost savings from potentially averted spinal fusions among individuals with adult spinal deformity in the United States (2024 USD)

Parameter	Value		Source
	Commercial	Medicare	

Medical resource use for scoliosis by adults, %	0.502	1.531	[20,21]
Adult scoliosis patients per 100,000 beneficiaries, n	502	1531	<i>Derived</i>
Convert from nonoperative care to spinal fusion (annual), %	21.7	21.7	[22]
Conversions to spinal fusion (annual), n	109	332	<i>Derived</i>
Absolute risk reduction in intent for surgery, %	11	11	SRT Survey
SRT participation rate (users), %	28	28	[23]
Spinal fusions averted annually per 100,000 beneficiaries, n	3.4	10.2	<i>Derived</i>
Spinal fusion insurer payment, \$ ^{a, b}	123,551 ^c	60,269	[13,24,25]
Annual cost savings per 100,000 beneficiaries, \$	414,534	616,504	<i>Derived</i>

Notes:

^aWeighted average of DRG 456 (spinal fusion with spinal curvature with MCC, 25%), DRG 457 (spinal fusion with spinal curvature with CC, 59%), and DRG 458 (spinal fusion with spinal curvature without CC/MCC, 16%).

^bInflated from 2022 to 2024 (half) USD using the Consumer Price Index for hospital services; multiplier 1.097.

^cCalculated using a Medicare-to-commercial payment multiplier of 2.05 for hospital inpatient services.

Abbreviations: CC, complication; DRG, diagnosis related group; MCC, major complication; SRT, Scoliosis Realignment Therapy; USD, United States dollars.

Data exclusion

Users with prior spinal fusion surgery were excluded from the surgical intent analysis. Participants were given two weeks to respond to the survey, with subsequent reminders. Users who failed to

respond to the surgical intent questions were excluded.

Ethical Considerations

This web-based survey evaluated a wellness program, not a medical treatment, and study data were de-identified for privacy and confidentiality protection. The datasets generated and analyzed during this study were restricted to the researchers conducting the analysis. NSC members who participated in the web-based survey study were provided \$50 gift cards for completion of the survey.

Per the Office of Human Research Protections, under the US Department of Health and Human Services, research that 1) involves only survey procedures of adults and 2) is collected in a deidentified fashion, is exempt from IRB review and informed consent can be waived (<https://www.hhs.gov/ohrp/regulations-and-policy/decision-charts-2018/index.html#c1>). A retrospective IRB approval was obtained for this study, confirming that both conditions are met and therefore this study was IRB exempt, and informed consent was not indicated.

Results

User Statistics

In total, 160 NSC members were invited to participate in the survey; 62 (38.8%) individuals nationwide voluntarily completed the survey. Six participants were excluded from the intention to pursue surgery analysis; five who had prior fusion surgery and one who did not respond. Among survey respondents who reported age (N=47), the mean age was 65.3 (SD 13.5) years (age <65 years, 40%; age 65+ years, 60%). Mean SRT duration of use was 118 days (SD 86.6); the majority were female (98%) and white (98%) (Table 2).

Table 2: Demographics and clinical characteristics of SRT cross-sectional survey participants with adult spinal deformity (N=62).

Characteristic	
Age in years, mean (SD)	65.3 (13.5)
Age <65, n (%)	19 (30.6)
Age 65+, n (%)	28 (45.2)
Did not respond	15 (24.2)
Gender, n (%)	
Female	47 (75.8)
Male	1 (1.6)
Did not respond	14 (22.6)
Race, n (%)	
White	45 (72.6)
American Indian and Caucasian	1 (1.6)
Did not respond	16 (25.8)
SRT Duration of Use in days, mean (SD)	118 (86.6)
Offered scoliosis surgery in the past, n (%)	
Yes	
No	
Did not respond	15 (24.2)
	26 (41.9)
	21 (33.9)
Prior fusion surgery for scoliosis, n (%) ^a	
Yes	5 (8.1)
No	56 (90.3)
Did not respond	1 (1.6)

^aIndividuals with either prior fusion surgery or no response excluded from surgical intent analysis.
Abbreviations: SRT, Scoliosis Realignment Therapy; SD, standard deviation

Evaluation Outcomes: Surgical Intent

Overall, 14% of participants (8/56) reported a decrease in intent for scoliosis surgery (that is, a lower Likert score) with use of SRT, and no participants reported an increase in surgical intent. The mean intent for surgery scores before compared to after SRT were 1.29 (SD 0.53) and 1.14 (SD 0.35), respectively (mean difference 0.15 [$P=0.006$]) (Table 3). Participants with “No Intent” for spinal surgery pre- versus post-use of SRT (42/56 versus 48/56, respectively) corresponds to an absolute risk reduction (ARR) of 11% and a number needed to treat (NNT) of 9 to potentially avert one spinal fusion (1 divided by 0.11). Among the six participants who transitioned to “No Intent” for spinal surgery with use of SRT, three were <65 years (ages 30, 62, and 64) and three were ≥65 years (ages 73, 73, and 82).

Table 3. Intentions for surgical intervention for adult spinal deformity prior to and after using SRT (cross-sectional survey) (N=56)

Statement	Percentage of Respondents				Mean	Standard Deviation
	No Intent	Low Intent	Moderate Intent	High		
1. Have you ever intended to have scoliosis surgery?	75.0	21.4	3.6	0.0	1.29 ^a	0.530
2. Since you have started working with the NSC SRT, what is your current intention to have scoliosis surgery?	85.7	14.3	0.0	0.0	1.14 ^a	0.353

^aFour-point Likert scale, where 1=No Intent for Surgery, 2=Low Intent, 3=Moderate Intent, and

4=High Intent. $P=0.006$, Wilcoxon signed-rank test.

Evaluation Outcomes: Estimated Cost Savings by Averting Spinal Fusion

The percentage of adult patients using medical services for scoliosis is 0.502% (age 18-64 years) and 1.531% (age 65+ years) for commercial and Medicare, respectively; or, 502 and 1531 per 100,000 beneficiaries, respectively (Table 1). An estimated 21.7% of these patients convert from nonoperative care to spinal fusion annually. Applying the SRT-related 11% absolute risk reduction and an assumed 28% SRT participation rate based on digital health wellness intervention programs without incentives, a total of 3.4 fusions would potentially be averted annually per 100,000 commercially-insured beneficiaries and 10.2 fusions potentially avoided annually per 100,000 Medicare beneficiaries. Applying a Medicare payment of \$60,269 for hospital inpatient spinal fusion (weighted average of DRGs 456-458 in 2024 USD) and multiplier for Medicare-to-commercial payment of 2.05 (that is, commercial payment of \$123,551), the annual cost savings from averted surgeries were estimated at US \$415,000 per 100,000 commercially-insured beneficiaries, and US \$617,000 per 100,000 Medicare beneficiaries (Table 1).

Discussion

Principal Findings

This web-based, cross-sectional survey study explored whether use of SRT, a personalized digital therapy program for adults with scoliosis, resulted in a reduction in intent for spinal surgery. After using SRT for an average of 17 weeks, a 11% ARR in intent for surgery was observed, which corresponds to a NNT of 9 – suggesting that one spine surgery could potentially be averted for every nine individuals using SRT. Hence, SRT offers a promising nonoperative therapy that may decrease spinal fusions with its associated risks and economic burden.

Comparison with Prior Work

The reduced intent in pursuing surgery with use of SRT is consistent with other digital care programs in orthopedics, recognizing that scoliosis is a unique condition with its own clinical challenges. For a 12-week digital care program in low back pain Shebib et al. demonstrated a significant reduction in surgical interest ($p=0.01$) [15]. Similarly, Smittenaar and colleagues reported a decrease in surgery intent at 3 months ($p<0.001$) with a 12-week digital care program for chronic knee pain [16]. Mecklenburg et al. also found that self-reported likelihood of having surgery decreased over 1 year with use of a digital care program for chronic knee pain ($p=0.01$) [17].

Investigators have reported conversion rates from nonoperative to operative treatment ranging from 12.7% (24/189) within one year to 31% (42/135) after six months [18,22]. Clohisy et al. further noted that the majority (90%) of patients crossed over from nonoperative to operative treatment due to perceived worsening of symptoms and the remainder because the patients believed that the nonsurgical therapies were ineffective [18]. Rhode et al. recently reported outcomes following six weeks of SRT using SRS-22r [19]. Specifically, a significant improvement in the Pain ($p<0.001$), Self-Image ($p=0.05$), and Mental Health ($p<0.001$) subdomains of the SRS-22r was observed, with the improvement in the Pain subdomain exceeding the minimal clinically important difference (MCID) threshold. In addition, these investigators reported high satisfaction with the SRT program (9.5 out of 10, where 1=Extremely Dissatisfied and 10=Extremely Satisfied) [19]. Given that the SRT cohort reported in Rhode et al. ($N=23$) is a subset of those reported herein ($N=62$), the statistically significant decrease in intent for surgery is consistent with the previously reported perceivable improvement in pain with use of SRT. These consistent findings across SRT studies support the validity of using the question on surgical intent to extrapolate to estimated cost-savings.

In light of the aging population among other factors, Wadhwa and colleagues reported that, among

both commercial and Medicare beneficiaries, the rate of fusion for adult spinal deformity surgery doubled from 2007 to 2015 [26]. In addition, Passias et al. reported the mean 2-year cost of nonoperative treatment at \$2041 and the mean 2-year cost for operative treatment at \$66,860 based on Medicare reimbursements [9]. As such, the estimated cost savings for averted surgeries reported in the present study are likely underestimated for multiple reasons; specifically, the percentage of beneficiaries seeking medical care for scoliosis is based on data from 2013 [20], the DRG reimbursement amounts reflect only the spinal surgery hospitalization (including the global period) [13], and incentives could increase the SRT participation rate [23].

The cost analyses are based on the best available published data, recognizing that more recent trends in insurer reimbursement and technological advancements may not be reflected. The cost-savings estimates rely on several assumptions including a 28% participation rate for intervention-focused digital wellness programs. Mattke et al. [23] described the relationship between incentive structure and participation rate noting that use of incentives increased wellness program participation. Our analysis assumed no incentives with an intervention-focused participation rate of 28% (versus 30% if any incentives). Others have reported a 32% participation rate for physical well-being programs [27]. Hence, assuming the absence of incentives offers a conservative estimate of participation rate.

Limitations

There are several limitations to this formative research study. First, participants used SRT for an average of 17 weeks, which begs the question about whether the observed decrease in surgical intent would be sustained. That said, Smittenaar et al. found that the reduction in surgery interest continued for six months following initiation of a digital health program for chronic knee pain ($p < 0.001$) [16], and Mecklenburg reported that the decreased likelihood of knee surgery with use of a digital care program was sustained over 5 years ($p = 0.002$) [17]. Second, the self-reported survey data are

subjective and participants completed both the pre- and post-SRT questions about surgical intention after initiating SRT, which potentially may be subject to recall bias. Third, the pre-post study design may be subject to confounding because it lacks an independent control or comparison group and is less rigorous than a randomized control trial; notwithstanding, each participant served as their own control. Further, study participants were not blinded in that they were aware of using SRT, which may have introduced the possibility of performance bias. Lastly, although participants represented a nationwide sample of adults with scoliosis, the study included a relatively small cohort that did not permit exploration of nuanced effects and was not ethnically diverse; therefore, the results may not be generalizable. Future studies will explore the durability of SRT use on surgical intent with a larger, more diverse cohort.

Conclusions

SRT is a personalized, scoliosis-specific digital health exercise program with the potential for averting 1 spinal fusion for every 9 participants, resulting in a substantial reduction in payer expenditures while improving quality of care for commercial payer and Medicare beneficiaries. The SRT remote, digital care program holds promise as a feasible strategy to transform the nonoperative paradigm in adult spinal deformity. Digital care delivery is becoming more common with currently available health technology, and can increase patient agency and engagement, while improving overall outcomes and decreasing healthcare spend.

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MCB was involved in the conceptualization, data analysis, interpretation of findings, and manuscript preparation. CQL was involved in the conceptualization, interpretation of findings, and manuscript preparation. CJ was involved in the conceptualization, data acquisition, data analysis, and manuscript preparation. MR was involved in the conceptualization and manuscript preparation. BR, JEB, and

BIW were involved in the conceptualization, manuscript preparation, and critical manuscript review. SJA was involved in the conceptualization, data analysis, interpretation of findings, manuscript preparation, and critical manuscript review. Generative AI was not used in any portion of the manuscript writing.

Data Availability

The datasets generated and analyzed during this study are available from the corresponding author on reasonable request.

Conflicts of Interest

SJA declares to have an advisory contract with NSite Medical. All other authors have no conflicts of interest to disclose.

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Supplementary Files

Attached is an updated version of our manuscript with tracked changes.

URL: <http://asset.jmir.pub/assets/5367dae6a5b0e34c6ade108304797b5d.docx>

CONSORT (or other) checklists

Please find attached a copy of the checklist Improving the Quality of Web Surveys - The Checklist for Reporting Results of Internet E-Surveys (CHERRIES).

URL: <http://asset.jmir.pub/assets/1dd9da2fabe8afcd9e5b3d93865485fc.pdf>

Related publication(s) - for reviewers eyes onlies

Please find attached a copy of our responses to the editors comments.

URL: <http://asset.jmir.pub/assets/753a7c2f9d3f380a769242eca4cbdd99.pdf>