

Original Article

Is prehabilitation a void in management of anterior cruciate ligament injuries? A Prospective study

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Abstract

Objective: The objective of this paper is to study the effects of 12 weeks of pre surgery physiotherapy rehabilitation protocol on the outcome of arthroscopic Anterior cruciate ligament reconstruction surgery. **Methods:** A prospective randomised clinical study was conducted to compare the functional outcome after ACL reconstruction surgery in patients who had received 12 weeks of pre surgery physiotherapy against those who had not received the same, based on clinical outcome, Tegner Lysholm and International Knee Documentation Committee Subjective Knee Form (IKDC) Score. **Results:** Out of 30 participants 15 participants who received pre-rehabilitation showed better functional score in terms of Tegner Lysholm score and IKDC score following ACL reconstruction surgery compared to group 2 which is non- pre-rehabilitation group. There was a statistically significant relation between Pre-rehabilitation and better functional scores. **Conclusion:** A prehabilitation programme emphasizing on intensive muscle strength training, plyometric exercises and advanced neuromuscular exercises gives better outcome than no prehabilitation and should be included in standard ACL treatment protocol for patients undergoing ACLR.

Keywords: Anterior Cruciate Ligament Reconstruction, Knee Arthroscopy, Pre-operative Care, Pre-operative Rehabilitation

Introduction

Injuries to the knee ligaments specially the anterior cruciate ligament (ACL) have high prevalence, especially in sports and sports-related activities. When these ligaments rupture, the balance between knee mobility and stability is disrupted, resulting in aberrant knee kinematics and injury to other tissues in and around the knee joint, resulting in morbidity and discomfort¹. While a large proportion of injured patients have surgical ACL reconstruction (ACLR) to restore mechanical stability in the knee joint, there is little evidence to suggest how to best combine surgery and rehabilitation to improve knee function. Given the fact that ACLR outcomes aren't perfect, there's a pressing need to keep looking for strategies to improve patient outcomes².

Prior to ACLR, patients were advised to undergo preoperative rehabilitation, commonly known as pre-rehabilitation (Prehab), to assist them prepare physically and mentally for surgery and postoperative therapy^{3,4}. Prehabilitation is intended to improve pre- and postoperative physical function by exercise training intervention, in addition

to bridging a long preoperative period till surgery and so preventing further deterioration of symptoms⁵. According to Wilk et al the pre-operative phase of rehabilitation following an acute ACL injury is important to the overall effectiveness of the ACL reconstruction process⁶. According to current literature, the pre-operative rehabilitation should aim for the following: 1) education and mental preparation; 2) full knee extension; 3) a 20% pre-operative quadriceps strength deficiency; 4) a normal gait pattern; 5) minimal edema and 6) reducing the chances of a second ACL injury^{5,6}.

The authors have no conflict of interest.

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While the majority of current research has focused on the impact of postoperative rehabilitation protocols, there are very few evidence-based guidelines for the management of early-stage ACL injuries that include clear descriptions of rehabilitation programs and outcome evaluation. As a result, little is known regarding the tolerance for short-term progressive exercise rehabilitation regimens in the early stages of ACL injury, as well as their potential effectiveness⁷⁻⁹.

The aim of the current study is to evaluate the effects of preoperative rehabilitation on the outcome of ACL reconstruction.

Materials and methods

This is a prospective case control study conducted at a high-volume tertiary care hospital in Navi Mumbai, India. Prior to beginning with the study ethical approval was taken from the ethical institutional board. The study duration was set to between August 2020 to January 2021. Informed consent was taken from all the participants included in the study. The inclusion criteria were set to include all patients belonging to the age group of 18-60 years with isolated chronic ACL injury of the knee with minimal swelling or pain, while those with acute ACL injury or associated PCL, meniscal tear, periarticular fracture, Grade 3 & 4 chondral injuries or ipsilateral lower limb fractures were excluded from the study. A meticulous history and clinical examination were conducted including checking of preoperative quadriceps strength. The diagnosis was finalized with clinical tests & with the help of MRI (Sigma HDxT-GE 1.5 Tesla). The outcome measures were taken before and after the study.

Participants and Randomization

Patient meeting the inclusion and exclusion criteria were randomly assigned to one of 2 groups based on coin flip method. One group received preoperative rehabilitation for 12 weeks course of combined scheduled direct OPD based and home-based physiotherapy under online supervision facilitated through telemedicine apps before surgery. The direct Out Patient Department (OPD) sessions helped to achieve correct level of difficulty along with performance of the perturbation sessions while compliance and performance at home was monitored through teleconsultation, thereby avoiding unnecessary in-patient admissions (Group A). The second group underwent ACL reconstruction without Prehab physiotherapy after 12 weeks of waiting period (Group B).

Preoperative Rehabilitation

The Preoperative rehabilitation aimed at increasing the muscle strength and regaining adequate neuromuscular responses thereby emphasizing on intensive muscle strength training, plyometric exercises and advanced neuromuscular exercises. Standardized strength training program was followed according to ACSM guidelines and performed for maximum of 6 sessions per week, which was done with 3 to 4 sets and 8 to 10 repetitions per set in each session.

Patient was asked to perform plyometric exercises under direct supervision in OPDs which included variations of single-leg hops and sets focused on maintaining the knee-over-toe position with soft landings. Further, neuromuscular challenges were added through proprioception and balance exercises such as single-legged squats on balance pads. A sequence of 10 sessions with perturbation training was also done with the participants under direct supervision in OPD. It included balance and stability exercises on custom-made rocker board progression of the perturbation training sessions was based on the guidelines from the University of Delaware. As stated by Wilk et al. [6] in their work pre-operative focus on proprioceptive and neuromuscular control activities to give a neurological stimulus improves the post-operative course of rehabilitation and recovery.

For reducing swelling and pain associated with physiotherapy Ice packs were applied for 20 minutes of each hour till swelling reduced along use of Pharmacotherapy (oral Tramadol 25mg sos for pain, oral Thiocolchicoside 4mg twice a day, oral Pantoprazole 40 mg once daily and oral Fixed dosed combination of Bromelain+ Trypsin+Rutoside thrice a day), Topical Magnesium sulphate dressing and limb elevation (with knee in full extension and above the level of heart) were used if required. The sessions were accompanied with use of an appropriately sized long knee brace or hinged knee brace.

The Peri operative and post operative period

All the participants were re assessed under anesthesia and there after they underwent diagnostic arthroscopy to rule out associated injuries followed by arthroscopic reconstruction of the ACL ligament using an ipsilateral allograft. Standard post operative protocols were followed for both the groups. Immediately after ACLR, the limb was immobilized in a postoperative functional brace, and patients were instructed to perform straight leg raising and quadriceps strengthening exercises. Patients were allowed to undergo partially weight bearing at 2 weeks after their surgery and to move through full-range of knee joint motion and perform closed chain exercise at 4 weeks after surgery. The patients were recalled for regular follow ups at 3rd, 6th and 12th month after the surgery. Tegner Lysholm score and IKDC score at the end of 12 weeks after presentation which was counted as pre operative score and at as above said follow up periods.

Statistical Analysis

Pre-operatively and post operatively data was analyzed with Clinical tests such as Lelli's test and Lachman tests, International Knee documentation Committee (IKDC) score and Tegner Lysholm score. The preoperative and post operative scores were expressed as mean +/- SD. The data was examined for normality. Initial comparison was done using unpaired T test. If the scores followed normal distribution they were compared between pre- and post-

	Group A		Group B		p-Value
	Mean	Standard Deviation	Mean	Standard Deviation	
Age	24.73	5.37	30.73	10.17	0.064
Height	165.53	6.54	163.40	6.69	0.433
Weight	65.06	11.77	66.67	8.71	0.715
BMI	23.62	3.31	24.90	2.60	0.295
Duration from injury at presentation (months)	8.93	3.45	9.33	8.07	0.741

Table 1. Comparison between Group A (group which has received pre operative rehabilitation) and Group B (patients who have not received pre operative rehabilitation).

Tegner Lysholm score	Group	N	Mean	SD	SEM	t-stat	df	p-value
Pre-OP	Prehab	15	73.333	12.298	3.175	-0.375	28	0.7104
	No prehab	15	74.800	8.833	2.281			
At 3 months	Prehab	15	87.733	7.126	1.840	4.467	28	0.0001
	No prehab	15	75.200	8.205	2.118			
At 6 months	Prehab	15	97.000	5.451	1.407	6.962	28	0.0000
	No prehab	15	81.333	6.800	1.756			
At 12 months	Prehab	15	99.867	0.516	0.133	8.802	28	0.0000
	No prehab	15	87.133	5.579	1.440			

Table 2. Comparison of Tegner lysholm score at various durations score over 12 weeks.

operative time points using paired sample t-test. $P < 0.05$ level of significance was chosen to declare the result to be significant. Comparison of the two groups through different time points (pre- and post-surgery) was done using repeated measure ANOVA. Greenhouse-Geisser/lower bound corrections were used when the sphericity test was not satisfied. Significance of different time points were tested using Pillai's traces method and reported using the corresponding F statistic. Post hoc comparison was done using Bonferroni correction for significant time points.

Results

Table 1 shows various demographic details of group A which received pre operative physiotherapy or prehabilitation for 12 weeks and group B which did not receive any physiotherapy. As we can evaluate based on the table there was no statistical difference between the groups based on demographic details.

The table also indicates comparison of duration of injury before presentation of subjects to hospital in both the

groups. The mean duration of surgery among study subjects in Prehab group i.e., group A was (8.933 ± 3.423) months and the mean duration of surgery study subjects group B was (9.333 ± 3.068) months. The result of unpaired t-test indicates no significant difference in the mean duration of surgery of study subjects in two groups ($t = -0.335$, $p = 0.7405$).

To compare outcome scores between the two groups unpaired student T test and repeated measure ANOVA was used. All the variables are approximately normally distributed.

Tegner Lysholm score Comparison

The Table 2 indicates comparison of Tegner Lysholm Score (TL Score) of subjects in Prehab and No prehab group. The mean Pre-op TL score of study subjects in Prehab group was (73.333 ± 12.298) and the mean pre-op TL score of study subjects in No prehab group was (74.800 ± 8.833) . The result of unpaired t-test indicates no significant difference in the mean pre-op TL score of study subjects in two groups ($t = -0.375$, $p = 0.7104$).

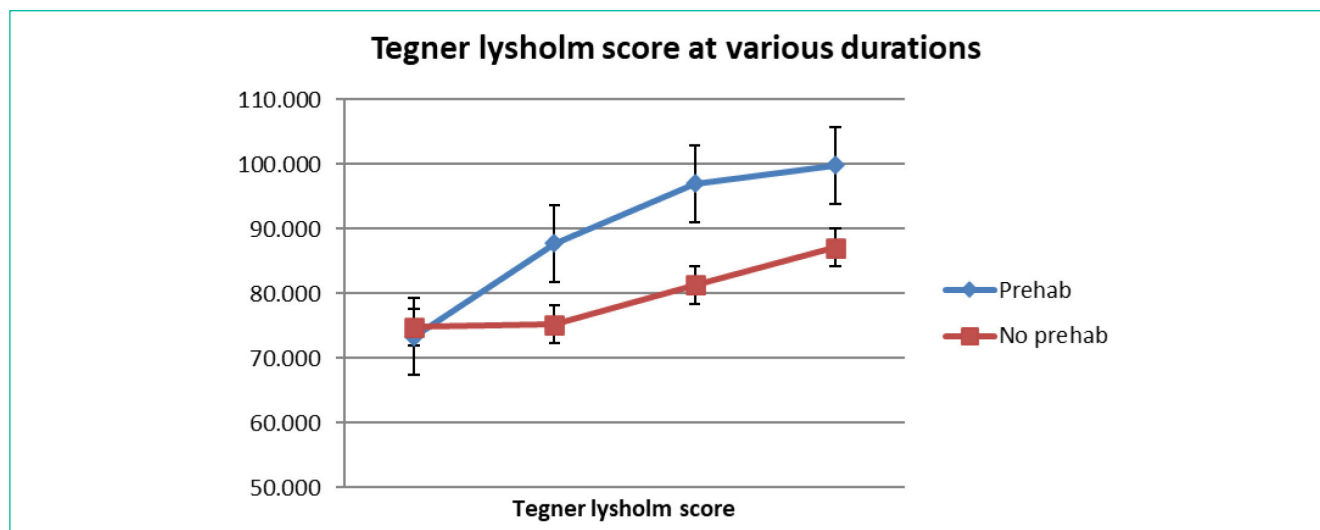


Figure 1. TL score at preop followed by post op 3, 6 and 12 months.

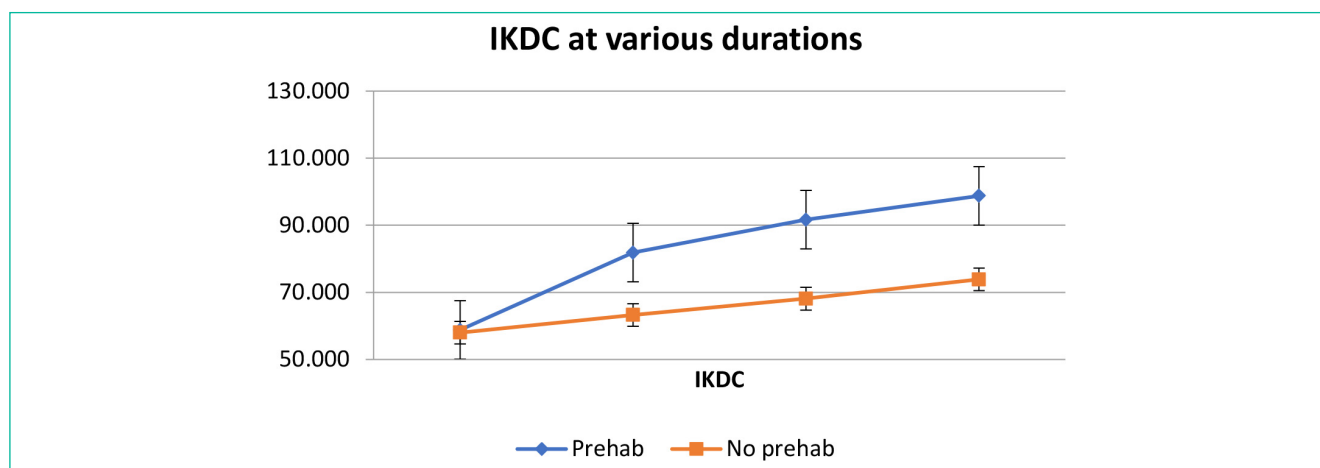


Figure 2. IKDC score at preop followed by post op 3, 6 and 12 months.

The mean TL score at 3 months of study subjects in Prehab group was (87.733 ± 7.126) and the mean TL score at 3 months of study subjects in No prehab group was (75.200 ± 8.205) . The result of unpaired t-test indicates significant difference in the mean TL score at 3 months of study subjects in two groups ($t=4.467$, $p=0.0001$).

The mean TL score at 6 months of study subjects in Prehab group was (97.00 ± 5.451) and the mean TL score at 6 weeks of study subjects in No prehab group was (81.333 ± 6.800) . The result of unpaired t-test indicates significant difference in the mean TL score at 6 months of study subjects in two groups ($t=6.962$, $p<0.001$).

The mean TL score at 12 months of study subjects in Prehab group was (99.867 ± 0.519) and the mean TL score at 12 months of study subjects in No prehab group was (87.133 ± 5.579) . The result of unpaired t-test indicates significant difference in the mean TL score at 12 months of study subjects in two groups ($t=8.802$, $p<0.001$).

Except for the post-op-12-week Tegner Lysholm score, all of the variables had homogeneous variances, according to Leven's homogeneity test. Mauchly's sphericity test indicates that the sphericity assumption is not met ($p<0.05$). The test can be carried out using Greenhouse-Geisser adjustment since Greenhouse-Geisser $\epsilon=0.65$, which is less than 0.75.

IKDC	Group	N	Mean	SD	SEM	t-stat	df	p-value
Pre-OP	Group A	15	58.800	10.171	2.626	0.263	28	0.7949
	Group B	15	58.000	5.988	1.546			
3 months	Group A	15	81.867	6.791	1.754	8.538	28	0.0000
	Group B	15	63.267	5.007	1.293			
6 months	Group A	15	91.667	4.337	1.120	14.051	28	0.0000
	Group B	15	68.133	4.824	1.245			
12 months	Group A	15	98.800	2.569	0.663	14.127	28	0.0000
	Group B	15	73.867	6.334	1.636			

Table 3. Comparison of IKDC score at various durations of follow up periods between the prehab group i.e., Group A vs those in no prehab group i.e., Group B.

It can be concluded that different time points (pre-op, post-op 3 months, post-op 6 months, and post-op 12 months) had a significant effect on Tegner Lysholm score ($F(3,26)=40.6$, $p<0.001$), according to Pillai's Trace technique. It can also be inferred that the Tegner Lysholm score is significantly affected by the duration of prehab ($F(3,26)=8.5$, $p<0.001$) (Figure 1).

The average Tegner Lysholm score differed considerably between pre-op, post-op-3 months, post-op-6 months, and post-op 12 months, according to repeat measure ANOVA (Greenhouse-Geisser adjusted $F(2.0, 61.5)=68.62$, $p<0.001$). There is also a significant difference in average Tegner Lysholm score between the prehab and no prehab groups ($F(1,28)=19.1$, $p<0.001$). A posthoc comparison using Bonferroni correction suggests that there is a significant increase in Tegner Lysholm score between all pairs of time points with $p<0.001$.

International Knee Documentation Committee Subjective Knee Form (IKDC) Score comparison

Table 3 indicates comparison of IKDC score of subjects which received prehabilitation (Group A/ Prehab Group) and those who didn't receive it (Group B/ No prehab group). The mean Pre-op IKDC score of study subjects in group A was (58.80 ± 10.171) and the mean pre-op IKDC score of study subjects in No prehab group was (58.000 ± 5.988). The result of unpaired t-test indicates no significant difference in the mean pre-op IKDC score of study subjects in two groups ($t=-0.263$, $p=0.7949$).

The mean IKDC score at 3 months of study subjects in Prehab group was (81.867 ± 6.791) and the mean IKDC score at 3 months of study subjects in No prehab group was (63.267 ± 5.007). The result of unpaired t-test indicates significant difference in the mean IKDC score at 3 months of study subjects in two groups ($t=8.538$, $p<0.001$).

The mean IKDC score at 6 months of study subjects in Prehab group was (91.667 ± 4.337) and the mean IKDC

score at 6 months of study subjects in No prehab group was (68.133 ± 4.824). The result of unpaired t-test indicates significant difference in the mean IKDC score at 6 months of study subjects in two groups ($t=14.051$, $p<0.001$). The mean IKDC score at 12 months of study subjects in Prehab group was (98.800 ± 2.569) and the mean IKDC score at 12 months of study subjects in No prehab group was (73.867 ± 6.334). The result of unpaired t-test indicates significant difference in the mean IKDC score at 12 months of study subjects in two groups ($t=14.127$, $p<0.001$).

Except for the post-op-12-month IKDC score, all of the variables had homogeneous variances, according to Leven's homogeneity test. Mauchly's sphericity test indicates that the sphericity assumption is not met ($p<0.05$). Lower bound adjustment can be used to run the test. It may be inferred using Pillai's Trace method that distinct time points (pre-op, post-op 3 months, post-op 6 months, and post-op 12 months) had a significant effect on IKDC score ($F(3,26)=247.0$, $p<0.001$). The combined effect of time points and prehab use has a significant influence on IKDC score ($F(3,26)=65.5$, $p<0.001$).

The average IKDC score differed considerably between pre-op, post-op-3 months, post-op-6 months, and post-op-12 months, according to repeat measure ANOVA analysis (Lower bound adjusted $F(2.0, 61.5)=421.75$, $P<0.001$). It can also be inferred that the average IKDC score between the prehab and no prehab groups differs significantly ($F(1, 28)=89.86$, $p<0.001$). There is a substantial rise in average IKDC score between all pairs of time points, according to a post-hoc comparison using Bonferroni correction, with $p<0.001$ (Figure 2).

Discussion

Any surgeon's unceasing quest is to enhance outcomes and patient satisfaction rates, which may be done by discovering new regimes in various pre or post operative modalities. Physiotherapy or rehabilitation before the

surgery termed as “preoperative rehabilitation” or “pre-rehabilitation”, is the phase of physical preparation for the period of immobility post ACL reconstruction surgery. The primary aim of this study was to understand the importance of pre-rehabilitation in the improvement of the knee joint function after ACL reconstruction surgery as compared to the group which received physiotherapy only after the surgery was done and to assess the functional outcome using the IKDC and Tegner Lysholm scores, at 3rd, 6th and 12th month post-surgery.

A total of 276 patients presented with ACL injuries, out of which 42 patients who met the inclusion criteria were enrolled in the study. Informed written consent was taken from all the participants included in the study and regular follow up was taken up to 12 months. At the end of follow up period 9 patients were lost to follow up while 3 had adverse events, and hence were not included in the study.

The average IKDC score differed significantly between pre-op, post-op-3 months, post-op-6 months, and post-op-12 months (Lower bound adjusted $F(2.0, 61.5)=421.75$, $P 0.001$). It can also be deduced that the average IKDC score changes significantly between the prehab and no prehab groups ($F(1, 28)=89.86$, $p 0.001$). According to a post-hoc comparison using Bonferroni correction, there is a significant increase in average IKDC score between all pairs of time points, with $p 0.001$. IKDC score is significantly influenced by the combined effect of time points and prehab use ($F(3,26)=65.5$, $p0.001$).

Similar to these findings according to repeat measure ANOVA (Greenhouse-Geisser adjusted $F(2.0, 61.5)=68.62$, $p 0.001$), the average Tegner Lysholm score differed significantly between pre-op, post-op-3 months, post-op-6 months, and post-op 12 months. The average Tegner Lysholm score differs significantly between the prehab and no prehab groups ($F(1,28)=19.1$, $p 0.001$). There is a substantial increase in Tegner Lysholm score between all pairs of time periods, according to a posthoc comparison using Bonferroni correction, with $p 0.001$. It can also be deduced that the length of prehab has a substantial impact on the Tegner Lysholm score ($F(3,26)= 8.5$, $p0.001$).

According to the results of the investigation, the mean IKDC and Tegner Lysholm scores increased among all 30 patients when compared to preoperative values, implying that functional scores improved after ACL reconstruction. We also discovered that Post operative IKDC and Tegner Lysholm scores improved significantly over time at 3,6, and 12 monthly assessments in both groups, thereby confirming the fact that increased duration of physiotherapy betters clinical outcome.

As the results suggests out of 30 participants 15 participants who received pre-rehabilitation showed better functional score in terms of Tegner Lysholm score and IKDC score, following ACL reconstruction surgery compared to non-prerehabilitation group. These findings are in accordance with similar studies done in past such as the one of Shaarani

et al¹⁰ where after following 6 weeks of prehab, the single-legged hop test results improved significantly in exercise - injured limb compared with baseline thereby stating that a 6-week progressive prehabilitation program for patients undergoing ACLR led to improved knee function based on the single-legged hop test and self-reported assessment using the modified Cincinnati score.

In their study, Palmieri Smith et al^{11,12} looked at the connection between preoperative quadriceps activation and postoperative quadriceps strength and activation in patients with ACL injuries who were awaiting surgery. They came to the conclusion that people with higher pre-operative strength had higher post-operative strength. Pre-operative activation and strength are connected to post-operative activation and strength, respectively suggesting that doctors should use strength-targeting therapies prior to ACL repair in order to maximize these parameters post-ACL reconstruction. These findings are in line with what we discovered in our research.

Kim et al study¹³ which focused on outcomes of 4 weeks prehabilitation prior to ACLR concluded that the findings showed preoperative workouts not only reduced quadriceps weakness, but also sped muscular strength recovery, allowing patients to adjust to the rehabilitation environment more quickly. It also expected that improved strength and function will reduce the risk of re-injury.

These findings strengthen the outcome of our study that preoperative physiotherapy improves functional outcomes after ACL repair. The study has several limitations, one of which is the one-year follow-up time. To determine the long-term ramifications of our findings, more research is required. In addition, the prehab and non-prehab samples are not matched in terms of injury mechanism. One of the limiting factors includes the small sample size in this study. The study also hasn't considered co morbid conditions of the patients such as arthritis which may affect outcome of the surgery.

Conclusion

A prehabilitation regime emphasizing on intensive muscle strength training, plyometric exercises and advanced neuromuscular exercises should be included in standard ACL treatment protocol for patients undergoing ACLR. Because there is no uniform prehabilitation protocol in terms of exercises or time period, a large multicentric study will aid in the standardization of a prehabilitation protocol thus allowing it to be reproduced across numerous sites.

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