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Isokinetic Evaluation of the Shoulder After Bristow/Latarjet Surgical Procedure in Athletes*

Avaliação isocinética do ombro após procedimento cirúrgico de Bristow/Latarjet em atletas

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Abstract

Objectives To evaluate the muscular strength of the internal (IR) and external (ER) rotators of the shoulder after Bristow/Latarjet surgery.

Methods Cross-sectional study with 18 patients (36 shoulders). The isokinetic evaluation was performed using the Biodex 3 System Pro dynamometer (Biodex Medical System, Inc., Shirley, NY, USA). The athletic shoulder outcome rating scale (ASORS) and the visual analogue scale (VAS) were applied.

Results The values of peak torque and maximum work in concentric and eccentric mode on the non-operated shoulder were higher than on the operated side for both the IR and ER ($p < 0.01$). The conventional and functional balance between the ER and IR showed no differences between the operated and the non-operated side. When comparing patients with postoperative time < 1 year or 1 year, no differences were observed in peak torque values at 60°/s and 240°/s and maximum work at 60°/s and 240°/s of the IR to the operated shoulder. However, the peak torque values of 60°/s and 240°/s and maximum work at 60°/s and 240°/s of the ER were higher in subjects with postoperative time ≥ 1 year in all variables ($p < 0.05$).

Conclusions There was a decrease in the strength of the IR and ER in the operated shoulder compared with the healthy shoulder. However, the conventional and functional balance was maintained.

Keywords
- shoulder dislocation
- orthopedic procedures
- isokinetic evaluation

* Study developed at the Sports Traumatology Center of the Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

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Resumo

Objetivos Avaliar a força muscular dos rotadores medial (RM) e lateral (RL) do ombro após cirurgia de Bristow/Latarjet.

Métodos Estudo transversal com 18 pacientes (36 ombros). A avaliação isocinética foi realizada por meio do dinamômetro *Biodex 3 System Pro* (Biodex Medical System, Inc., Shirley, NY, EUA). A escala de avaliação dos resultados do ombro do esportista (EROE) e a escala visual analógica (EVA) da dor foram aplicadas.

Resultados Os valores do pico de torque e o trabalho máximo no modo concêntrico e excêntrico no ombro não-operado foram maiores que no lado operado tanto para o RM e para o RL ($p < 0,01$). O equilíbrio convencional e funcional entre s RL e o RM, não apresentou diferenças entre o lado operado e o não operado. Na comparação entre pacientes com o tempo pós-operatório < 1 ano ou ≥ 1 ano, não se observou diferenças nos valores do pico de torque em 60°/s e 240°/s e do trabalho máximo em 60°/s e 240°/s do RM para o ombro operado. No entanto, os valores de do pico de torque em 60°/s e 240°/s e do trabalho máximo em 60°/s e 240°/s do RL foram superiores em indivíduos com tempo pós-cirúrgico ≥ 1 ano em todas as variáveis ($p < 0,05$).

Conclusões Houve diminuição da força do RM e do RL no ombro operado em relação ao ombro saudável; porém, o equilíbrio convencional e funcional foi mantido.

Palavras-chave

- luxação do ombro
- procedimentos ortopédicos
- avaliação isocinética

Introduction

The glenohumeral joint is the one with the greatest mobility in humans. This large range of motion, together with the low bone congruence between the glenoidal cavity and the humerus head, gives it greater susceptibility to displacement.[1,2]

The Bristow/Latarjet stabilization procedure is a surgical treatment described for recurrent anterior shoulder dislocation in patients with capsular and bone deficit. Both the open and arthroscopic procedures produce excellent clinical results with low recurrence rates.[3–9]

In fact, one of the major postoperative concerns are complications, usually reported as decreased or loss of shoulder range of motion. This issue is of great relevance in current sports medicine, because the return to the sports gesture prior to the injury is paramount for the athlete. Transfer through the subscapularis muscle represents a violation of the most important active stabilizer of the glenohumeral joint. This surgical aggression can lead to atrophy and imbalance of the shoulder muscles.[10–15]

In this sense, the evaluations of images and isokinetics have been reported, both in the selection of patients with better surgical indication and in the postoperative period, allowing an adequate and targeted rehabilitation program. However, a few studies have described specific problems that would affect the shoulder joint system after anterior instability surgery through the isokinetic methodology, whose evaluation can serve as a useful tool for the athlete's return to sport.[11–15]

The objectives of the study were: to evaluate the functional result; to evaluate the muscle strength of the internal and external rotators of the shoulder after Bristow/Latarjet surgery; to analyze the association between the strength pattern and the time of surgery, and to verify whether there is an association between the loss of range of motion with the isokinetic parameters. The hypothesis is that Bristow/Latarjet surgery leads to a decrease in the strength of the IR and ER with maintenance of functional balance.

Methodology

This is an observational, cross-sectional study that analyzed patients treated from January 2013 to December 2017 at the shoulder outpatient clinic of our institution. All participants signed a free and informed consent form for participation in the research before data collection. The project was approved by Plataforma Brasil and the Research Ethics Committee with CAAE number: 89698818.5.0000.5505.

Athletes diagnosed with traumatic anterior shoulder instability with the Bristow or Latarjet postoperative time greater than 6 months were included.

The non-inclusion criteria were previous shoulder surgery, presence of associated lesions, such as rotator cuff injury or superior labrum anterior and posterior (SLAP) lesions, and presence of lesions in the contralateral shoulder.

Patients who presented pain or discomfort during isokinetic evaluation were excluded.

The present study included 23 patients whose sample size was based on a series of cases operated in our institution. However, three patients who had already undergone a previous surgical procedure and two patients who presented alterations in the contralateral shoulder (anterior instability) were excluded. Thus, a total of 18 patients (36 shoulders) were evaluated.

The patients were selected according to the flowchart for surgery of anterior glenohumeral instability of the shoulder and elbow group of the discipline of sports medicine of our institution (►**Figure 1**). Surgical procedures were performed by means of general anesthesia associated with brachial plexus block with the patient positioned in a beach chair.

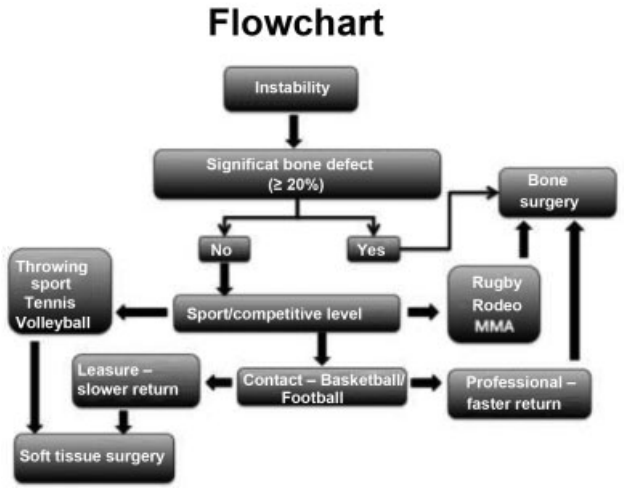

Fig. 1

Fig. 2 *Biodex 3 System Pro* ® dynamometer.

The deltopectoral approach was performed with an incision of approximately 5 cm, followed by osteotomy of the coracoid process and fixation of the graft in the anteroinferior region of the glenoid through a longitudinal incision in the middle third of the subscapularis tendon, with one or two screws (Bristow or Latarjet). The coracoacromial ligament was not sutured. All patients participated in the same rehabilitation protocol as our institution. A velpeau-like spoy was maintained for 3 weeks full-time, starting after the 3rd week controlled passive movements as well as scapular control exercises. After the 6th week the active exercises were initiated and after 10 weeks strengthening and stretching exercises were introduced. The return to the sport was allowed after 4 months.

The study participants answered a specific demographic questionnaire and the following scores, which were translated and previously validated to Portuguese for evaluation of the functional result: athletic shoulder outcome rating sclae (ASORS)[16] , which assesses the stability of the shoulder, range of motion and pain (poor results - 50 points; good results 75–89 points and excellent results 90–100 points), and the visual analogue scale (VAS).

Isokinetic Evaluation

The isokinetic test is characterized by the evaluation of muscle strength at a constant and prefixed speed. The isokinetic evaluation was performed using the *Biodex 3 System Pro* dynamometer (Biodex Medical Systems, Inc., Shirley, New York, USA) (►**Figure 2**). The patients were positioned in the dynamometer chair with the shoulder at 45° abduction (scapula plane), elbow at 90° flexion with neutral forearm. The range of motion was fixed at 90° (45° ER and 45° IR) according to Davies' methodology, which allows greater reproducibility and lower risk of seizure compared to shoulder at 90°.[14] This position has a more advantageous biomechanics because it provides maximum safety and comfort in the tests. This is due to the greater congruence of the articular surfaces, which in addition to maintaining a neutral position, relaxes the capsular structures and puts the muscles in a more advantageous position.[18]

The tests were performed with 1 minute of recovery between each examination. The athletes performed 4 repetitions in concentric mode at speeds of 60°/s and 240°/s and 4 repetitions in eccentric mode at 60°/s (standard protocol) (►**Figure 3**).

The following isokinetic variables were analyzed:

- Peak torque (Newtons-meters/kg)
- Maximum work (joules/kg)
- Conventional Balance (concentric ER/concentric IR) 60°/s (%)
- Functional Balance (eccentric ER/concentric IR) 60°/s (%)

The maximum work and maximum torque of external and internal shoulder rotators were normalized by body mass. Among the measures adopted, the maximum work is the one that most represents muscle function, because it indicates the production of force throughout the contraction amplitude, while the maximum torque measures only one point or peak force within the total amplitude.[19]

The main evaluation of shoulder goniometry was performed with the patient lying down, with a shoulder in 90-degree abduction and a 90-degree elbow flexion. The internal and external rotation were evaluated in the sagittal plane with the aid of a Carci brand goniometer made of PVC, measuring 22 cm long and 0.8 mm thick, comparing the amplitude of the range of motion of the operated shoulder with that of the healthy one.

Statistical Analysis

To test the homogeneity between the proportions, the chi-squared test or Fisher exact test was used. The mean between two groups after surgery was compared through the paired Student t-test, because the data are paired, that is, when the same subject is research and control of himself. Differences were considered statistically significant if they had a significance level of 5% ($p < 0.05$).

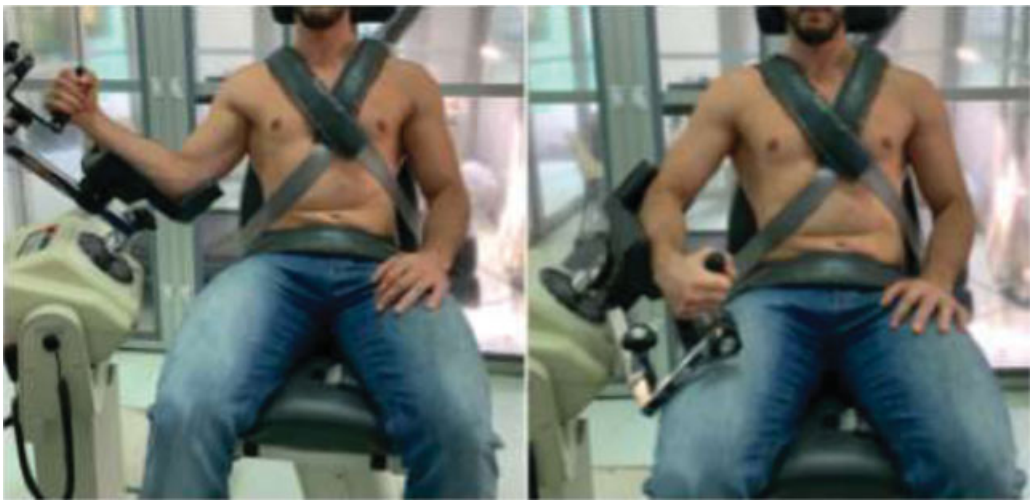

Fig. 3 Photo of the patient's isokinetic evaluation.

Results

The mean age of the athletes was 26.7 years, ranging from 19 to 38 years. The mean ASORS score[16] was 91.0, 62.5% excellent and 37.5% good. The visual analog pain scale had an average lower than 1. The average return time to sport was 4.81 months, with a maximum time of 6 months and a minimum of 4 months.

In the comparison of the isokinetic evaluation of the internal rotator between the operated and non-operated side, a statistically significant difference was observed. The mean peak torque and the maximum work at 60°/s and 240°/s by the standard protocol in the non-operated shoulder was higher than the average of the operated side, presenting $p \leq 0.01$ (►**Table 1**).

The isokinetic evaluation of the external rotators between the operated and non-operated side also showed a statistically significant difference. Like the analysis of the internal rotator, the mean values of peak torque and maximum work by the standard protocol in the non-operated shoulder were higher on the operated side, presenting $p \leq 0.01$ (►**Table 1**).

When we evaluate the conventional and functional balance between the external and internal rotators (►**Table 2**), we can verify that there are no differences between the averages found on the operated versus non-operated side.

In order to analyze whether the results of the isokinetic evaluation could be influenced by the time elapsed after the surgical procedure, the patients were divided between those with less than 1 year from surgery and those with 1 year or more (►**Table 3**). For the operated shoulder, it was observed that the values of peak torque and maximum work by the standard protocol of the internal rotator did not present differences. However, when considering the values of peak torque and maximum work by the standard protocol of the external rotator were higher in individuals with postsurgical time equal to or greater than 1 year in all variables, $p \leq 0.05$.

The conventional balance of 60°/s also presented statistical differences, with $p \leq 0.001$, and patients with 1 year or more since surgery had a higher mean than individuals with less than 1-year of postsurgical time. For the non-operated shoulder, no statistical difference was observed ($p \geq 0.05$) between the isokinetic variables.

In order to ascertain whether angular loss of movement influenced isokinetic evaluation, the patients were divided into less than 10 degrees loss and greater than or equal to

Table 1 Isokinetic evaluation of internal and external rotators

		Internal rotator		External rotator	
		Average/SD	*P*	Average/SD	*P*
Peak torque 60°/s (Nm/kg)	Operated	0.487 ± 0.116	< **0.001**	0.252 ± 0.081	**0.002**
	Non-operated	0.589 ± 0.157		0.328 ± 0.094	
Peak torque 240°/s (Nm/kg)	Operated	0.411 ± 0.149	**0.004**	0.188 ± 0.079	**0.001**
	Non-operated	0.471 ± 0.160		0.265 ± 0.123	
Maximum work 60°/s (J/kg)	Operated	47.9 ± 11.5	< **0.001**	23.0 ± 8.4	< **0.001**
	Non-operated	60.0 ± 16.1		33.5 ± 10.0	
Maximum work 240°/s (J/kg)	Operated	34.3 ± 13.6	<**0.001**	13.1 ± 7.0	**0.001**
	Non-operated	42.6 ± 16.7		20.1 ± 9.1	

Abbreviations: SD, standard deviation; CI, confidence interval.
Student paired t-test was used considering $p < 0.05$ values as statistically significant difference.

Table 2 Isokinetic balance assessment

Balance		Average	*P*
Conventional (ERc/IRc) 60°/s (%)	Operated	51.9% ± 13.7%	0.199
	Non-operated	56.3% ± 12.0%	
Functional (ERecc/Rc) 60°/s (%)	Operated	2.68 ± 1.86	0.568
	Non-operated	2.54 ± 1.59	

Abbreviations: SD, standard deviation; CI, confidence interval.
Student paired t-test was used considering $p < 0.05$ values as statistically significant difference.

Table 3 Isokinetic evaluation of the internal and external rotators of operated shoulder in patients with postsurgical time < 1 year and 1 year

Isokinetic Time (Operated)		Average ± SD	*P*
Peak torque 60°/s IR (%)	< 1 year	0.469 ± 0.148	0.546
	≥1 year	0.506 ± .079	
Maximum work 60°/s IR (J)	< 1 year	43.4 ± 13.0	0.123
	≥1 year	52.4 ± 8.4	
Peak torque 240°/s IR (%)	< 1 year	0.382 ± 0.173	0.46
	≥1 year	0.440 ± 0.125	
Maximum work 240°/s IR (J)	< 1 year	32.8 ± 17.5	0.679
	≥1 year	35.8 ± 9.3	
Peak torque 60°/s ER (%)	< 1 year	0.191 ± 0.065	< 0.001
	≥1 year	0.314 ± 0.036	
Maximum work 60°/s ER (J)	< 1year	16.9 ± 7.2	0.001
	≥1 year	29.0 ± 4.1	
Peak torque 240°/s ER (%)	< 1year	0.147 ± 0.075	0.034
	≥1 year	0.228 ± 0.063	
Maximum work 240°/s ER (J)	< 1year	9.4 ± 5.6	0.03
	≥1 year	16.8 ± 6.6	
Conventional balance (ERc/IRc) 60°/s (%)	< 1year	41.2% ± 9.9%	< 0.001
	≥1 year	62.6% ± 6.4%	
Functional balance (ERecc/Rc) 60°/s (%)	< 1year	2.60 ± 2.20	0.866
	≥1 year	2.77 ± 1.60	

Abbreviations: SD, standard deviation; CI, confidence interval.
Student paired t-test was used considering $p < 0.05$ values as statistically significant difference.

10 degrees loss. For the operated shoulder (►**Table 4**), no statistical differences were observed in any of the isokinetic variables ($p \geq 0.05$).

Discussion

Our study involved the isokinetic evaluation of 36 shoulders of 18 athletes submitted to Bristow-Latarjet surgery. In foreign literature, we found few articles on this evaluation after Bristow-Latarjet surgery.[10–12,20–22] In the national literature, we found only the Castropil[22] study that performed an isokinetic evaluation after repairing a Bankart lesion associated with anteroinferior capsuloplasty. This evidences the importance of this evaluation, considering the scarcity of national and international references.

There was a comparison between isokinetic measurements between the operated shoulder and the healthy contralateral shoulder after Bristow-Latarjet surgery, as well as in previous studies.[10,19,20,23] Nevertheless, other methods have been described, such as the comparison between shoulder before and after surgery.[20,21]

The ASORS score[16] in our patients was good in 37.5% and excellent in 62.5%, and this score had not been evaluated previously. Meanwhile, Wredmark et al.[18] evaluated factors related to ASORS,[16] such as mobility, strength, and stability, and found good or excellent values in 42 of 44 patients (95%).

The methodology of isokinetic evaluation is not homogeneous in the literature,[18–20] and many studies present protocols with 30° or 0° abduction,[19] while in our study the evaluations were performed with 45° abduction. While we

Table 4 Isokinetic evaluation of the internal and external rotators of operated shoulder according to angular loss of movement < 10 degrees and 10 degrees

Loss External Rotation		Average	*P*
Peak torque 60°/s IR (%)	<10	0.460 ± 0.123	0.359
	10	0.515 ± 0.110	
Maximum work 60°/s IR (J)	<10	47.8 ± 13.5	0.959
	10	48.1 ± 10.1	
Peak torque 240°/s IR (%)	<10	0.351 ± 0.110	0.109
	10	0.471 ± 0.165	
Maximum work 240°/s IR (J)	< 10	30.9 ± 12.9	0.329
	10	37.7 ± 14.3	
Peak torque 60°/s ER (%)	< 10	0.250 ± 0.083	0.925
	10	0.254 ± 0.085	
Maximum work 60°/s ER (J)	< 10	24.4 ± 8.7	0.51
	10	21.5 ± 8.5	
Peak torque 240°/s ER (%)	< 10	0.169 ± 0.069	0.35
	10	0.207 ± 0.087	
Maximum work 240°/s ER (J)	< 10	11.9 ± 6.3	0.522
	10	14.3 ± 7.9	
Conventional balance (ERc/IRc) 60°/s (%)	< 10	53.9% ± 11.2%	0.565
	10	49.9% ± 16.3%	
Functional balance (ERecc/Rc) 60°/s (%)	< 10	2.80 ± 2.15	0.807
	10	2.56 ± 1.66	

Abbreviations: SD, standard deviation; CI, confidence interval.
Student paired t-test was used considering $p < 0.05$ values as statistically significant difference.

fixed a range of motion (ROM) of 90° (45° internal rotation and 45° external rotation) and angular velocities of 60°/s and 240°/s, Wredmark et al.[19] presented angular velocities of 30°/s and 90°/s (without demonstrating ROM), Dauty et al.[20] had angular velocities of 60°/s and 120°/s with ROM of 105° (60° internal rotation and 45° external rotation), Edouard et al.[21] presented angular velocities of 60°/s, 120°/s and 180°/s with 70° ROM (15° internal rotation and 55° external rotation) and Caubère et al.[10] had angular velocities of 60°/s, 180°/s and 240°/s with 60° ROM (30° internal rotation and 30° external rotation).

In our results, the mean peak torque and the maximum work by the standard protocol in the non-operated shoulder was higher than the mean of the operated side for the internal (IR) and external (ER) rotators, presenting $p \leq 0.01$. We observed a deficit in the peak torque of the concentric mode of 17.3% of the IR and 23.2% of the ER at 60°/s, and 12.7% of the IR and 29.1% of the ER at 240°/s. Dauty et al.[20] found an almost complete recovery of shoulder strength after 3 months of surgery. However, a deficit in peak torque was reported in the operated shoulder eccentric mode of the IR in relation to the healthy shoulder of 9 to 15%.[20] Another study showed a significant reduction of strength in the concentric mode of 13% and 10% for the IR, and 19% and 10% for the ER for peak torque at 60°/s and 240°/s, respectively, of the operated versus healthy shoulder after 1 year of surgery[10] (►**Table 5**).

The analysis of the conventional and functional balance between the ER and IR showed no differences between the means found on the operated versus non-operated side. This evaluation is important to ascertain whether the shoulder is biomechanically stable. In the literature, the study by Caubère et al.[10] showed that shoulder functional balance was maintained after the Latarjet surgical procedure. The reason why there is a reduction in the strength of the ERs is not evident, and it can be conjecture that it is related to the simple process of muscle inactivation in the postoperative period.

Currently, the literature data are conflicting regarding the effects of Bristow-Latarjet surgery on isokinetic parameters. While the study by Wredmark et al.[19] showed that there is no change in muscle strength and range of motion of IR and ER after the surgical procedure, others showed a reduction in muscle strength.[10,12,22,23] Recovery time seems to be an important point, and our results associated with data from the literature have verified that function and range of motion can be restored with recovery time.

Our study presents as positive factors the homogeneity of the sample (all athletes), the follow-up of the Davies modification protocol, the unprecedented comparison of the loss of ROM amplitude with isokinetic evaluation and according to our knowledge, the present research is the first Brazilian study that addresses this theme. However, we had some limitations, such as the number of individuals is lower than

Table 5 Comparison of peak torque between different studies in the literature

Author	Evaluation	Peak torque	
		Internal Rotation	External Rotation
Wredmark et al., 1992	Operated x healthy shoulder	Similar	Similar
Dautya et al., 2007	Preoperative: Healthy X injured shoulder	Similar	Similar
	Postoperative: Operated x healthy shoulder	Similar	Similar
	Injured shoulder: preoperative X postoperative	Eccentric (9–15% defict)	Similar
Edouard et al., 2012	Injured shoulder: preoperative X postoperative	3M: -28% ± 20%	3M: -17% ± 17%
		6M and 21M: Similar	6M and 21M: Similar
Caubère et al., 2017	Healthy X operated shoulder	60°/S -13% // 240°/S -10%	60°/S -19% // 240°/S -10%
Ribeiro et al.	Operated x healthy shoulder	60°/S - 17.3% // 240°/S - 12.7%	60°/S - 23.2% // 240°/S - 29.1%

that of previous studies, ranging from 20 to 44 patients; the non-investigation of the correlation with subscapular imaging on magnetic resonance imaging to evaluate whether the loss of strength was due to muscle atrophy or fatty degeneration, and the non-assessment of graft consolidation. Due to the cross-sectional design, we could not characterize the differences in isokinetic evaluation in the pre and postoperative periods.

Thus, we believe that the isokinetic dynamometer can serve as an instrument of objective analysis of the shoulder, becoming an effective and safe tool for evaluation after Bristow-Latarjet surgery, since there are few criteria for returning to sport validated by the literature.

Conclusion

There was a decrease in the strength of the IRs and ERs in the operated shoulder in relation to the healthy shoulder after Bristow/Latarjet surgery; however, the conventional and functional balance was maintained.

There was greater strength of the ERs in the group with more than 1 year of surgery and the loss of ROM in 10 degrees of external rotation did not influence in the loss of strength.

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Conflict of Interests
The authors declare that there is no conflict of interests.

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