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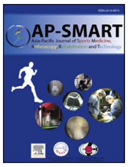

Original article

Change in muscle thickness under contracting conditions following return to sports after a hamstring muscle strain injury—A pilot study

Yasuharu Nagano [a,*], Ayako Higashihara [a,b], Mutsuaki Edama [c]

[a] Department of Health and Sports, Niigata University of Health and Welfare, Niigata, Japan
[b] The Japan Society for the Promotion of Science, Tokyo, Japan
[c] Department of Physical Therapy, Niigata University of Health and Welfare, Niigata, Japan

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Abstract

The purpose of this study was to measure the change in hamstring muscle thickness between contracting and relaxing conditions following a return to sports after a hamstring muscle strain and thereby evaluate muscle function. Six male track and field sprinters participated in this study. All had experienced a prior hamstring strain injury that required a minimum of 2 weeks away from sport participation. Transverse plane scans were performed at the following four points on the affected and unaffected sides under contracting and relaxing conditions: proximal biceps femoris long head, proximal semitendinosus, middle biceps femoris long head, and middle semitendinosus. The results demonstrated an increase in the thickness of the middle biceps femoris long head and middle semitendinosus regions on the unaffected side with contraction, whereas the affected side did not show a significant increase. The proximal semitendinosus muscle thickness was increased with contraction on both the unaffected and the affected sides. By contrast, the proximal biceps femoris muscle thickness did not show a significant increase on both sides. The results of this study show that evaluation of muscle thickness during contraction may be useful for assessing the change in muscle function after a hamstring muscle strain injury.

Keywords: after-effect; muscle; rehabilitation; sports injury

Introduction

Muscle strain—particularly hamstring muscle strain[1]—is one of the most common injuries associated with participation in intense sports and has a high reinjury rate, with reported values ranging from 12%[2] to 35%.[3] This high rate of hamstring muscle strain recurrence suggests that, after injury, the muscle undergoes changes that could be risk factors for future injury. Silder et al[4] examined bilateral differences in strength, neuromuscular patterns, and musculotendon kinematics during sprinting; however, no significant differences were found between previously injured and uninjured limbs. Thus, the reason for the high recurrence rate of hamstring muscle strain is still unclear.

The changes in muscle morphology after a strain injury are possible risk factors for recurrence and have been investigated previously. Silder et al[5] investigated long-term changes in muscle morphology following a hamstring muscle strain and demonstrated that many athletes are likely to be returning to sports with residual atrophy of the biceps femoris (BF) long head. Sanfilippo et al[6] investigated hamstring morphology at the time of return to sports and 6 months later, and showed that muscle volume decreased 4—5% in this time interval. Although these studies[5,6] did not examine the change of pennation angle or any other parameter to assess the change of

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* Corresponding author. Department of Health and Sports, Niigata University of Health and Welfare, 1398, Shimamicho, Kita-ku, Niigata 950-3198, Japan.

E-mail address: nagano@nuhw.ac.jp (Y. Nagano).

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hamstring muscle function, the presence of atrophy after hamstring muscle strain suggests that the hamstring muscle does not work normally. Therefore, it is possible that the function of the hamstring muscle changes after a strain injury.

Previous studies[5,6] using magnetic resonance imaging measured only static muscle volume, which could not be used to evaluate changes in muscle function following a strain injury. During the healing process after a strain injury, the muscle should undergo sufficient contraction for improving strength. Insufficient muscle contraction, caused by poor remodelling of muscles or neuromuscular inhibition,[7] leads to selective atrophy[5] or reinjury. To observe dynamic changes in a muscle, as under contracting conditions, ultrasonography is suitable because of its characteristic feature of providing real-time images. To observe the function of the transversus abdominis and lumber multifidus muscles, the changes of muscle thickness during rest and contraction are commonly measured.[8–10] However, there are no studies on changes in hamstring muscle function after a strain injury, assessed using ultrasonography.

The purpose of this study was to measure the change in hamstring muscle thickness between contracting and relaxing conditions after returning to sports from a hamstring muscle strain and thereby evaluate muscle function. This study provides a unique and basic understanding of changes in muscle function after a strain injury and of the risk factors for recurring hamstring muscle strain. As previous studies[5,6] have suggested that changes in muscle function occur following a return to sports after a hamstring muscle strain injury, we hypothesised that hamstrings, particularly the BF long head, would not demonstrate sufficient contraction or increased thickness under contracting conditions.

Methods

Participants

Participants who had experienced a prior hamstring strain injury that required a minimum of 2 weeks away from sport were recruited from the college track and field team. Six male track and field sprinters participated in this study {age, 20.3 [standard deviation (SD) 0.8] years; height, 1.77 [SD 0.05] m; weight, 66.8 [SD 2.5] kg; and best 100 m time, 10.88 [SD 0.23]}. At the time of this study, all participants had already returned to practice and had been participating in track and field. The time period from injury to return to sports was 2–8 weeks (median 6 weeks), and the time period after return to sports was 8–40 months (median 15 months; Table 1). If the participants had experienced multiple hamstring strain injuries, we treated the time period from injury to return to sports as the longest period between injuries. If the participant had experienced a hamstring strain injury in both legs, we treated the side with the more severe injury as the affected side. Prior to participation, all participants provided written informed consent in accordance with the Niigata University of Health and Welfare ethical committee requirements (17457) and the Declaration of Helsinki. The region of hamstring strain injury was determined, from an illustration on a questionnaire, as being proximal, middle, or distal. When possible, we also determined if the region was medial or lateral (Table 1).

Ultrasonography

Ultrasonography was performed using a Viamo SSA-640A (Nihon Kohden Corporation, Tokyo, Japan), a linear 7.5 MHz transducer, and two to three focal zones. Participants were positioned prone on the Biodex System 3 (Biodex Medical Systems, Inc., Shirley, NY, USA), with the shank fixed using a strap and the knees in 20° flexion. We selected the following four points for the transverse plane scans of the affected and unaffected sides, which can depict the muscle form but does not include the tendon: proximal BF, proximal semitendinosus (ST), middle BF, and middle ST. On a line from the ischial tuberosity to the fibular head or medial tibial condyle, the proximal point was set at 30%, and the middle point was set at 50%, from the ischial tuberosity. The scans were taken first under relaxing conditions and then under isometric contracting conditions. Participants were instructed to flex their knee to conduct isometric contraction until the muscle did not thicken. During the scan, the head of the transducer was fixed with a hand-made pad to unify the direction, and pressure was applied taking care not to transform the muscle. Two scans of each region were taken under each of the two conditions. From the scan image, the thickness of the BF and ST was measured using Scion Image (Scion Corporation, Torrance, CA, USA) (Fig. 1). The measurement was conducted three times, and an average of the three measurements for the two images was calculated. The intraclass correlation coefficients (ICC) (1, 2) values are shown in Table 2.

Table 1
Participant demographics and previous injuries.

Participant	Age (y)	Side	Location	Number of injuries (times)	Time from injury to return to sports (wk)	Months from return to sports (mo)
a	19	Right	Proximal	1	6	8
b	21	Left	Distal lateral Middle	2	8	15
c	21	Left	Proximal Middle lateral Middle medial Distal	6	6	25
d	20	Left	Proximal	1	7	40
e	21	Right	Middle	1	2	15
f	20	Left	Middle	1	4	12

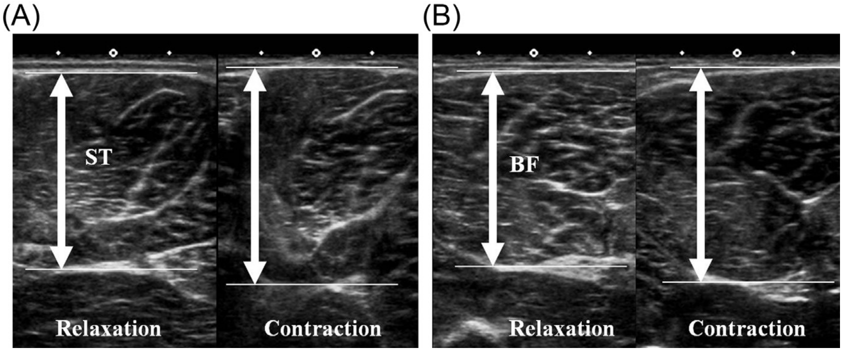

Fig. 1. Measurement of muscle thickness: (A) ST and (B) BF during relaxation (left) and contraction (right). BF = biceps femoris; ST = semitendinosus.

Table 2
ICC (1, 2) of muscle thickness in each part.

	Biceps femoris		Semitendinosus	
	Middle	Proximal	Middle	Proximal
Relaxation	0.96	0.98	0.84	0.97
Contraction	0.84	0.98	0.99	0.99

Strength testing

Hamstring muscle strength was measured as the peak torque during isokinetic contraction. Participants sat on an isokinetic dynamometer (Biodex System 4; Biodex Medical Systems, Inc.), with the hips in 90° flexion and the dynamometer and knee joint axes aligned. Each participant performed maximum-effort knee flexion/extension testing through the full range of motion by concentric contraction at 60°/s (3 repetitions). The peak joint torque (N m/kg) was recorded.

Statistical analysis

SPSS version 19.0 (SPSS Inc., Chicago, IL, USA) was used to conduct paired *t* test for the determination of the statistical significance of muscle thickness change between relaxing and contracting conditions in each region of the affected and unaffected sides, as well as the difference in the strength of hamstring muscles between the affected and unaffected sides. For muscle thickness analysis, the level of significance was set at $p < 0.05/8$, according to Bonferroni correction. The level of significance for hamstring muscle strength was set at $p < 0.05$.

Results

The comparative results are shown in Table 3 and individual alterations in Fig. 2. The proximal ST region was significantly thicker under the contracting condition than under the relaxing condition on the affected and unaffected sides. In the proximal BF region, there were no significant differences between the contracting and relaxing conditions on the affected and unaffected sides. The middle ST and BF regions were significantly thicker under the contracting condition than under the relaxing condition on the unaffected side, whereas the difference was insignificant on the affected side. Strength testing revealed a peak joint torque of 171.2 (33.3) N m/kg on the unaffected side and 178.1 (39.9) N m/kg on the affected side. The difference between the two sides was not significant.

Discussion

This study examined the change in the BF and ST muscle thickness between relaxing and contracting conditions for the affected and unaffected sides following a return to sports after a hamstring muscle strain injury. The results showed that in the middle BF and ST regions, the muscle thickness on the unaffected side was increased with contraction, while the affected side did not show a significant increase. In the proximal ST region, the muscle thickness of both the unaffected and the affected sides was increased by contraction. By contrast, the muscle thickness of the proximal BF region did not show a significant increase on either side. These results were useful for assessing the differences in muscle function change after a hamstring muscle strain injury.

Table 3
Muscle thickness of the biceps femoris and semitendinosus during relaxation and contraction.

	Biceps femoris				Semitendinosus			
	Middle		Proximal		Middle		Proximal	
	Unaffected	Affected	Unaffected	Affected	Unaffected	Affected	Unaffected	Affected
Relaxation	45.8 (5.4)[a]	46.9 (8.9)	40.5 (8.4)	37.8 (9.2)	37.9 (2.4)[a]	37.3 (3.7)	37.1 (4.7)[a]	35.7 (3.6)[a]
Contraction	50.4 (4.7)[a]	45.1 (7.3)	43.4 (8.8)	41.9 (11.5)	43.2 (3.4)[a]	40.7 (5.0)	43.9 (4.8)[a]	42.3 (3.1)[a]

Data are presented as mean (SD).

[a] $p < 0.05/8$ for differences between the relaxation and contraction conditions.

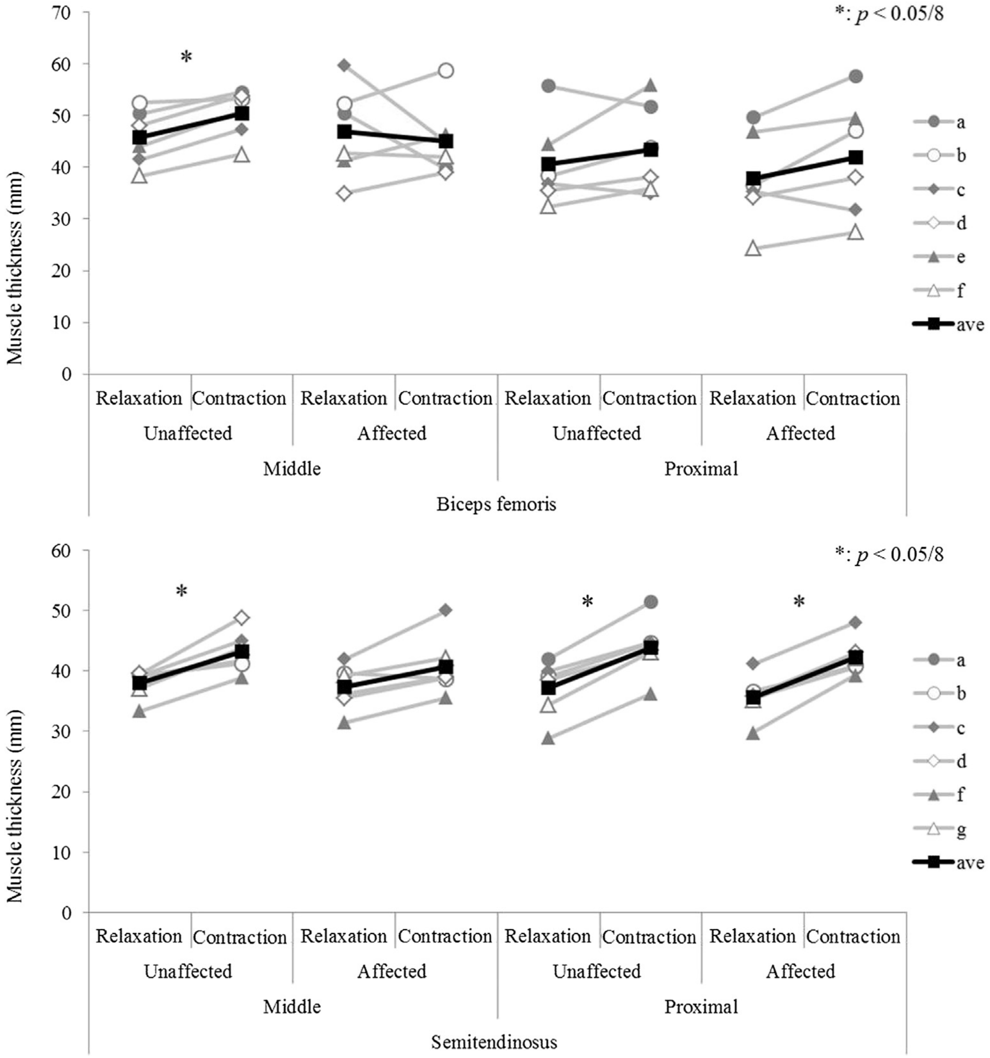

Fig. 2. Individual changes in muscle thickness between relaxing and contracting conditions.

We were able to evaluate the difference in muscle function between the unaffected and affected sides, based on these results of the middle regions of the BF and ST muscles. In a previous study, the volume of the injured muscle was decreased after a hamstring muscle strain injury.[5] However, after 6 months of return to sports, the isokinetic knee flexion strength of the injured and uninjured limbs was the same in another study.[6] This implies that isokinetic strength is not an index of hamstring muscle function after a strain injury. We examined the change in muscle function after a muscle strain injury under contracting and relaxing conditions based on an ultrasonographic evaluation of muscle thickness. The results of the middle regions of the BF and ST muscles, indicated that the BF and ST muscle thickness of the affected side was not increased under contracting conditions. These results demonstrated insufficient recovery of muscle function after a strain injury in athletes who had returned to sports. Muscle thickness did not increase during contraction in some participants (participants a and c for the BF, and participant b for the ST). Following a muscle strain, the muscle undergoes remodelling as well as neuromuscular inhibition.[7] There is a possibility that these changes are the cause of insufficient muscle contraction after a hamstring muscle strain injury. This insufficient muscle function may lead to recurrent injuries. With the use of an ultrasonographic evaluation of the middle regions of the BF and ST during contracting and relaxing conditions, muscle function deficiency can be assessed at the time of return to sports or following return to sports after a hamstring muscle strain.

It was difficult to evaluate muscle function in the proximal BF and ST regions after the strain. The changes in the BF between the contracting and relaxing conditions followed a variable pattern on both the affected and the unaffected sides among the participants. It was difficult to determine if the change in the muscle thickness was caused by a hamstring muscle strain injury. The ST muscle thickness under the contracting and relaxing conditions was increased on both the affected and the unaffected sides. These results indicate that the hamstring muscle strain injury did not affect the muscle thickness in the proximal ST region. Therefore, the middle but not the proximal region of the hamstring muscles is suitable for an evaluation of muscle thickness under contracting and relaxing conditions.

There were some limitations to the present study. The region of the hamstring muscle injury was identified based on information obtained from a questionnaire. We could not definitively determine the injured muscle because a long time had passed after the participants' return to sports. However, this study showed the change in muscle function in the middle region of the muscle, regardless of the muscle that was injured. Additionally, the fact that many participants did not show an increase in the BF muscle thickness under the contracting conditions may indicate that a hamstring muscle injury often occurs in the BF.[11,12] Future studies should identify the injured muscle with the use of magnetic resonance imaging at the time of injury. Finally, the sample size of this study was small, and the degree of injury severity varied largely. Additionally, not all hamstring muscles were evaluated in this study. Therefore, future studies should examine, using a larger sample size, the difference between participants with and without recurrent injuries, including measurement of the thickness of other hamstring muscles.

Conclusion

We measured the change in hamstring muscle thickness between contracting and relaxing conditions after return to sports from a hamstring muscle strain and thereby evaluated muscle function. We were able to evaluate the difference in muscle function between the unaffected and affected sides based on the results of the middle regions of the BF and ST muscles, but not based on the results of the proximal regions.

Conflicts of interest

The authors declare no conflict of interest associated with this manuscript.

Acknowledgments

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