Changes in Cross-sectional Area of Psoas Major Muscle during Competitive Period in Male Sprinters

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試合期における男子短距離選手の大腰筋面積の変化

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要　旨

背景と目的：先行研究では男子スプリンターを対象に，試合期において大腰筋横断面積の変化を検討した報告は見当たらない。そこで，本研究は100mが10秒台後半の記録を有する大学男子短距離選手３名を対象に，試合期における大腰筋横断面積の変化について検討した。**方法**：３月下旬の試合期開始から約２ヶ月毎に合計４回，MRIを用いて大腰筋横断面積を測定した。**結果**：３名とも共通して，６月に大腰筋横断面積が最も肥大し，それ以降は減少する傾向がみられた。**結論**：対象がターゲットとしている試合が５～６月に開催されることから，それに向けたコンディションづくりに多くの試合に出場したこと，つまり全力疾走の頻度が多くなることにより，素早い脚のスイング動作を伴う股関節の屈曲伸展運動が激しくなり，大腰筋横断面積の肥大を生じさせる可能性が示唆された。一方，鍛練期に近づくにつれて大腰筋横断面積が減少していった理由としては，試合期の後半にも同程度の試合は開催されるが，対象の３名がそれらを必ずしもターゲットとしなかったこと，また加えて試合に出場する機会が少なくなり，高強度の走運動を実施する頻度が少なくなったことなどが可能性として示唆された。

Abstract

Background and aim: Previous studies have not reported changes in the cross-sectional area (CSA) of the psoas major (PM) muscle during competitive period in male sprinters. This study aimed to examine changes in the PM CSA during the competitive period for three university male sprinters with a record of 100m dash in

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the latter half of 10 seconds. ***Methods***: We measured the PM CSA by magnetic resonance imaging (MRI) for a total of 4 times and approximately every two months from the start of the competitive period in late March. ***Results***: Maximum hypertrophy of the PM CSA was seen in June and tended to decrease thereafter in all three subjects. ***Conclusion***: Temporal changes in the PM CSA of three male university sprinters were observed in the range of approximately −4% to +5% during six months of the competitive period. The peak of muscle hypertrophy was observed in June and the muscle mass of PM CSA has gradually decreased thereafter. The results of this study suggest that this approach using MRI is one of the most useful for assessing, timing of training initiation, and the effectiveness of future training.

キーワード：大腰筋，試合期，男子短距離選手
Keywords：psoas major muscle, competitive period, male sprinters

Introduction

One of the challenges in improving sprint performance is in how to strengthen the hip muscles during regular training. In particular, sprint performance is known to be closely related to the size of psoas major (PM) muscle, a hip flexor muscle. Many studies (Watanabe et al., 1999; Watanabe et al., 2000; Hoshikawa et al., 2006; and Hoshikawa et al., 2011) have reported that the larger cross-sectional area (CSA) of hip joint muscles, the higher the sprint speed.

Arai et al. (2004) measured the PM CSA of two female elite sprinters in Japan during the competitive period and the preparatory period. They reported that both sprinters showed notable hypertrophy of the PM CSA during the competitive period compared to the preparatory period. The main reason for it was the introduction of high-speed, high-intensity sprinting in the competitive period (Arai et al., 2004).

However, no previous study examined changes in the PM CSA during the competitive period for male sprinters. Thus, in this study, we examined the change in the PM CSA during the competitive period for three male university sprinters capable of sub 11 sec in 100m dash. We herein report the modest findings that we obtained.

Methods

Subjects

Three male university sprinters voluntarily participated in this study. All subjects were healthy and had no history of orthopedic disease. This study was conducted in accordance with the Declaration of Helsinki. The main objectives and methods were sufficiently explained to all subjects, and their informed consent for participation was obtained before initiating the study.

Age, body height, body mass, body fat percentage (%fat), and personal best time of 100m dash (100m PB) are summarized in Table 1. The 100m PB represent a record authorized by the Japan Association of Athletics Federations.

Table 1. Characteristics of subjects

Subject	A	B	C
Age, years	21	20	20
Body height, cm	175.4	174.2	166.3
Body mass, kg	66.2	58.8	61.3
%fat, %	10.3	4.5	7.2
100m PB, sec	10.92	10.85	10.89

Abbreviations: %fat, body fat percentage; 100m PB, personal best time of 100m dash.

Body composition

Body composition parameters including body mass, %fat, and LBM were measured indoors using a body composition analyzer (Inbody 720; Biospace, Tokyo, Japan) under a controlled temperature of approximately 25°C. The body composition analyzer uses multiple frequencies (1, 5, 50, 250, 500, and 1,000 kHz) for bio-electrical impedance analysis and contains eight-point tactile electrodes. The subjects were asked to remove their socks any metal objects, their hands and feet using special tissues containing electrolytes step on the electrode of the meter foothold, and hold the electrode bars naturally while the measurement was conducted. All subjects were instructed not to exercise, eat, or drink during the 2 hours before the measurement.

Measurement of PM CSA

The PM CSA was scanned and measured on both sides using a 1.5-tesla whole-body magnetic resonance imaging scanner (EXCELART Vantage; Toshiba Medical Systems, Tokyo, Japan). The subjects were placed in the supine position with the spine in a neutral position and a pillow under their knees. Then, a cross-sectional image was obtained at the level between L-4 and L-5 (McGill et al., 1993; Santaguida and McGill, 1995). All measurements were performed by the same radiological technologist, who had substantial clinical expertise. The PM CSA was then calculated by summing the pixels contained within the border of the PM tissue. The PM CSA was measured four times in total about every two months from the start of the competitive period in late March. The PM CSA stands for the total value of the left and right PM muscles.

Overview of typical weekly workout and annual workout period

Table 2 provides an overview of typical weekly workout during the competitive period.

Table 2. Typical weekly workout schedule during competitive period

	Speed	Strength	Plyometrics
Monday (super maximum velocity focus)	Block start dash, 2-3×30-50m Downhill sprints, 6×100m	Rest	Rest
Tuesday (speed endurance focus)	Block start dash, 2-3×30-50m Sprints, 3×100-200m Sprint relays, 3×100m	Rest	Rest
Wednesday (maximum velocity focus)	Block start dash, 2-3×30-50m Sprints, 10×50m	Bench press Half squat High clean pull Leg curl	Hurdle hops
Thursday	Rest	Rest	Rest
Friday (maximum velocity focus)	Block start dash, 2-3×30-50m Sprints, 3×100-200m Sprint relays, 3×100m	Rest	Rest
Saturday (speed endurance focus)	Block start dash, 2-3×30-50m Uphill sprint, 5-10×20-120m/ Stair sprints, 3-5×120 stairs	Rest	Single leg hops Alternate leg bounding
Sunday	Rest/ competition	Rest	Rest

The warm-up routine included light jogging, dynamic stretching, sprint drills, and wind sprinting (running at approximately 70% of maximum velocity). The cool-down routine included light jogging and static stretching. The strength training included 3 sets of 3-12 repetitions at 60-90% of 1 repetition maximum. Each training was performed with three sets of 3-12 repetitions.

Table 3 provides an overview of typical weekly workout schedule during the preparatory period.

Table 3. Typical weekly workout schedule during preparatory period

	Speed	Strength	Plyometrics
Monday (muscular strength and endurance focus)	Standing start dash, 3×30m Uphill sprint, 3×100m	Bench press Half squat High clean pull Leg curl	Rest
Tuesday (speed endurance focus)	Block start dash, 3×30–50m Sprints, 3–5×100–400m	Rest	Hurdle hops
Wednesday (muscular strength and endurance focus)	Standing start dash, 3×30m Piggyback uphill dash, 5×30m	Bench press Half squat High clean pull Leg curl	Box Jumps
Thursday	Rest	Rest	Rest
Friday (muscular strength and endurance focus)	Standing start dash, 3×30m Stair sprints, 5×120 stairs	Bench press Half squat High clean Leg curl	Rest
Saturday (maximum velocity focus)	Block start dash, 3×30–50m Sprints, 1–3×100–300m	Rest	Single leg hops Alternate leg bounding
Sunday	Rest	Rest	Rest

The warm-up routine included light jogging, dynamic stretching, sprint drills, and wind sprinting (running at approximately 70% of maximum velocity). The cool-down routine included light jogging and static stretching. The strength training included bench presses, half squats, high clean pulls, and leg curls. For each strength training session, the load was set at 60% to 80% of one repetition maximum. The strength training was performed with three to five sets of 5 to 10 repetitions and the total volume of the training depended on the progression of the training.

Table 4 provides an overview of annual workout period.

Table 4. Annual workout period

Months	Periods	Duration
Mar.		
Apr.		
May	competitive period	14-15 weeks
Jun.		
Jul.		
Aug.	preparatory period	4-5 weeks
Sep.	competitive period	10-11 weeks
Oct.		
Nov.	transition period	4-5 weeks
Dec.		
Jan.	preparatory period	14-15 weeks
Feb.		
Mar.		

Results

Figures 1 shows the changes in the PM CSA for each subject during the competitive period. The PM CSA of all three subjects was largest in June and clearly decreased thereafter. Figures 2 shows the change ratio for PM CSA during the competitive period. The change ratio = [(post-value - baseline-value) / baseline-value] ×100. The change ratio for PM CSA of subjects A, B, C was +1.3%, +5.1%, and +3.3% in June, +0.5%, -3.9% and -3.4% in August, -1.8%, -4.2%, -4.4% in November., respectively.

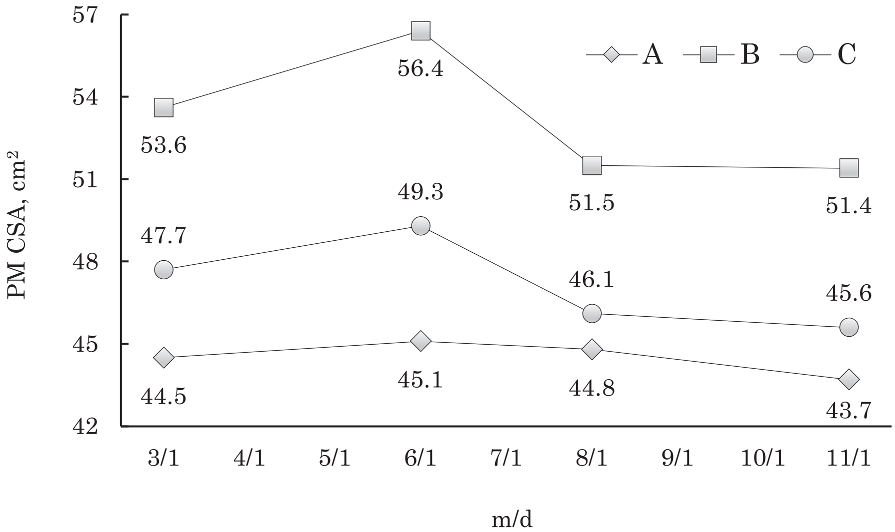

Fig. 1. Changes in PM CSA during competitive period
Abbreviations: A, subject A; B, subject B; C, subject C;
PM, psoas major muscle; CSA, cross-sectional areas; m/d, month/day

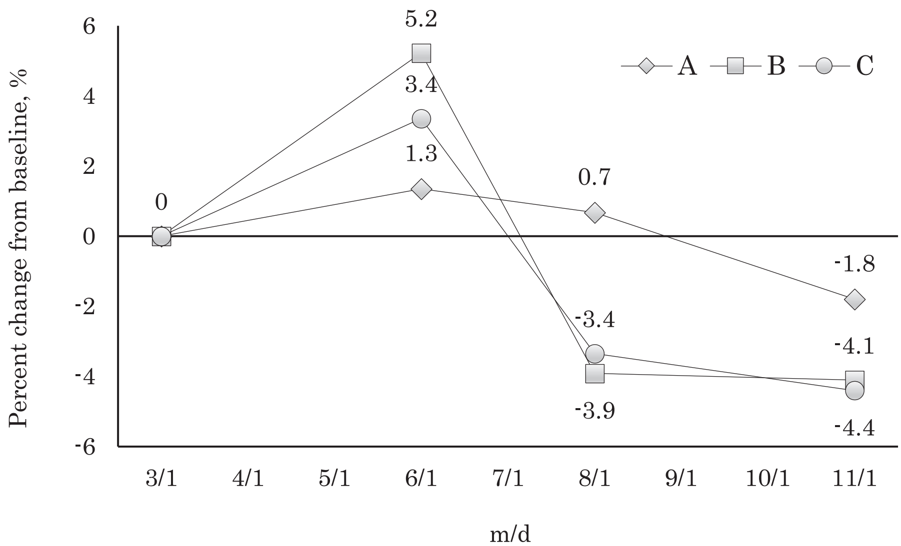

Fig. 2. Percent changes from baseline in PM CSA during competitive period
Abbreviations: A, subject A; B, subject B; C, subject C; m/d, month/day

Discussion

To date, there have been reports of many studies that examined the relationship between the PM CSA and sprint performance in various levels of sprinters. Most of the studies demonstrated a strong correlation between sprint speed and the PM CSA (Watanabe et al., 1999; Watanabe et al., 2000; Hoshikawa et al., 2006; Hoshikawa et al., 2011). In addition, NHK (Japan Broadcasting Corporation) also reported in 2008 that the PM CSA of Asafa Powell, who was the men's 100m dash world record holder at that time, was almost twice as large as that of the former Japanese record holder Nobuharu Asahara. Thus, a large the PM CSA in a sprinter is considered a major factor in determining the excellence of sprint performance.

However, there are few reports examining the relationship between changes in sprint performance and changes in the PM CSA, and this has not been fully understood. Arai et al. (2004) compared the muscle CSA of the thigh and the PM during the competitive period and the preparatory period in two elite female sprinters. They found that in both sprinters, though the CSA of muscle groups in the thigh showed a decrease, the PM CSA showed an increase during the competitive period. This suggests that during the competitive period, including sprint training and competitions, the frequency of sprint running increases; therefore, the hip joint flexion and extension movements associated with rapid leg swing movements become intense, causing hypertrophy of the PM. On the other hand, during the preparatory period, the number of competitions decreases, and the opportunity to sprinting at full speed during practice also decrease, suggesting a decrease of the PM CSA. It also suggests that regular weight training performed during the preparatory period is unlikely to be a load that causes hypertrophy of the PM. Therefore, it is important to perform fast and high-intensity sprinting and training of the hip flexors for the purpose of enlarging the PM. The future issue is how to incorporate these into the preparatory period.

In this study, the PM CSA was measured by MRI for a total of four times every two months approximately, from the start of the competitive period in late March in three university male sprinters with a record of 100m dash in the latter half of 10 seconds. Changes in the PM CSA during the competitive period were examined. In all three subjects, the PM CSA hypertrophy was highest around June and showed a decreasing trend as the preparatory period approached. Maximum the PM CSA hypertrophy around June for all three subjects in this study could be attributed to the fact that the target competitions were held from May to June (Kansai Inter-College Athletics Championships held in mid-May and Western Japan Inter-College Athletics Championships held in mid-June); hence, they participated in many competitions for conditioning preparation towards them. In other words, by increasing the frequency of sprint running, the hip joint flexion and extension movements intensify with rapid leg swing movements. This was suggested to likely induce hypertrophy of the PM CSA.

On the other hand, the PM CSA decreased as the preparatory period in the summer approached because the three subjects did not necessarily target similar competitions that were held in the second half of the competitive period. Moreover, their chances of participating in the competitions decreased and the frequency at which they performed high-intensity sprinting was likely reduced. In addition, it was suggested that the chances of participation in the competitions decreased, which in turn reduced the frequency of high-intensity sprinting.

One way to keep the PM CSA from decreasing during the competitive period or preparatory period is to maintain the frequency of high-intensity sprinting as much as possible. Manabe et al. (2012) reported that muscle strength training consisting of abdominal muscle exercises by leg-lifting, trunk solidifying sit-ups, and leg-pulling exercises resulted in the PM CSA hypertrophy and improved sprint performance. In addition, Nakata et al. (2013) also suggested that hip joint training using a device called "MULTI HIP JOINT BOARD" may likely induce the PM CSA hypertrophy and thereby improve sprint performance. These findings suggest that the PM in sprinters can be enlarged by muscle strength training in addition to high-intensity sprinting. In particular, a decrease in the PM CSA during the preparatory period can be prevented by performing high-intensity sprinting as much as possible and adding muscle strength training to strengthen the PM.

Conclusion

Temporal changes in the PM CSA of three male university sprinters were observed in the range of approximately −4% to +5% during six months of the competitive period.

The peak of muscle hypertrophy was observed in June and the muscle mass of PM CSA has gradually decreased thereafter. The results of this study suggest that the way using MRI is one of the most useful methods for assessing training, timing of training initiation, and the effectiveness of future training.

Limitations

The current study was limited by the small number of subjects, the fact that the changes over time in the PM CSA and that of sprint performance could not be examined simultaneously, and the lack of the PM CSA examination during the preparatory period. In the future a greater number of runners should be used to examine about these issues.

Conflict of interests

There were no conflicts of interest.

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