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ULTRASONOGRAPHIC COMPARISON OF ABDOMINAL MUSCLE THICKNESS BETWEEN ELITE SPRINTERS AND DISTANCE RUNNERS

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SUMMARY

The objective of the study is to compare the effects of high level sprinting and distance running on the abdominal muscles of respective athletes. Participants were 18 elite male runners selected without randomization, aged 18-22 (19.4 ± 1.3). The number of runners was nine in both running groups. Athletes had been running competitively for at least two years. Abdominal muscles anteroposterior (AP) thickness measurements were performed using a clinical ultrasonography (US) device, furnished with a curvilinear probe, emitting 7.5 MHz ultrasonic waves. Athletes were supine and still throughout the test. The probe was placed on two points on the left side of the abdomen, which are standard in abdominal muscle still image taking US. Statistically, AP thicknesses of all abdominal muscles were significantly different for the two groups of runners. The rectus abdominis (RA), the internal and external obliques (IO and EO) were thicker in sprinters; in contrast, the transversus abdominis (TA) was thicker in distance runners ($p<0.05$). These results may suggest that running training differences can influence muscle development and current morphology. Clearly, the TA muscle displayed greater AP thickness in distance runners. This phenomenon may be indicative that the increased activity of this muscle results from the cost effective strategy distance runners use to maintain performance. Besides, the difference might be due to respiratory function differences in the two groups. Furthermore, the combination of the obliques and RA might work together to facilitate forward leaning during sprinting, so that greater hypertrophy of these muscles is observed in the latter group.

Key words: Abdominal muscles, distance running, sprinting, ultrasonography

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ÖZET

ELİT SPRINTER VE MESAFE KOŞUCULARINDA ABDOMİNAL KAS KALINLIKLARININ ULTRASONOGRAFİ İLE KIYASLANMASI

Çalışmanın amacı üst düzeyde sprint ve mesafe koşusu antrenmanları yapan atletlerde abdominal kas kalınlıklarını karşılaştırmaktır. Rastgele seçim uygulanmayan katılımcılar 18-22 (19.4 ± 1.3) yaşlarındaki 18 elit koşuculardı. Her iki grupta dokuzar atlet yer aldı. Atletler en az iki yıldır üst düzeyde yarışıyordu. Abdominal kasların anteroposterior (AP) kalınlık ölçümleri kürvilineer probu olan ve 7.5 MHz'de dalga üreten bir klinik ultrasonografi (US) cihazı ile gerçekleştirildi. Atletler testler boyunca supin ve hareketsiz pozisyonda kaldılar. Prob gövdenin sol tarafında, US ile abdominal görüntü elde etmede standart olan iki noktaya yerleştirildi. Tüm abdominal kasların AP kalınlıkları iki grup koşucu için istatistiksel olarak anlamlı düzeyde farklı bulundu. Rectus abdominis (RA), internal ve eksternal oblikler (IO ve EO) sprinterlerde daha kalın iken; transversus abdominis (TA) mesafe koşularında daha kalın idi ($p<0.05$). Bu sonuçlar koşu antrenmanı farklılıklarının kas gelişimini ve ulaşılan morfolojisini etkileyebileceğine işaret edebilir. Mesafe koşucularında TA kası AP kalınlığı açık şekilde daha kalındı. Bu kassal aktivite, mesafe koşucularının performanslarını sürdürmek için geliştirdikleri düşük enerji maliyeti stratejisinden kaynaklanabilir. Bunun yanı sıra, farklar iki grup koşucu arasında respiratuvar fonksiyon farklarına bağlı olabilir. Ayrıca; RA ve oblik kasların birlikte çalışması sprint sırasında öne eğilmeyi kolaylaştırdığı için bu koşucularda söz konusu kaslarda daha fazla hipertrofi gözlenir.

Anahtar sözcükler: *Abdominal kaslar, mesafe koşuları, sprint, ultrasonografi*

INTRODUCTION

Abdominal muscles (AMs) have a dual role in stabilizing (18,19) and mobilizing the trunk (14), and they also act during respiration (1,21). Because of these physiological functions, AMs have always been the focus of research under various conditions (3,4,6,15,25). Starting with Engel and Deitch (10), the ultrasonographic assessment of muscular morphology, function and trophic changes, has recently become the interest of many researchers (1,2,4,6,7,8,13,14,23,24) studying the biomechanics of the trunk and/or the human body in general.

Ultrasonography (US) possesses some advantages over other muscle evaluation methods. For example, it is non-invasive and easy to use, so that it is becoming readily available in research, and has application to many muscles of the body (6). The equipment costs are considerably less than some other imaging equipments, such as magnetic resonance imaging (MRI).

The validity of muscle US has been established by comparing it with the golden standard measurement, namely MRI (12). Additionally, a significant linear relationship between electromyographic (EMG) activity and thickness of transversus abdominis, measured by both M- and B-mode US, has been established (20); adding more usability to the ultrasonographic assessment of the muscles. Since AMs participate in the locomotion, stabilization and also respiration, their function and role in sport activities, especially long term activities, can be a major concern for research. Besides, the effects of long term sport activities on the morphology of these muscles could be a good focus for investigation. So, this study was aimed at comparing the thickness of abdominal muscles, between elite sprinters and distance runners, using B-mode US measurements, in an attempt to relate it with muscle functionality.

MATERIAL and METHODS

Subjects: Participants were eighteen male professional sprinters and distance runners, whose ages ranged between 18-22 years (19.4 ± 1.4). This sample was recruited with no randomization, among those with inclusion criteria and without exclusion criteria, after acquisition of their consent. These athletes were matched in terms of their ages, precedence of sport activity and their body mass indices (BMI), so that the mean values of the above mentioned variables revealed no significant differences between the two groups. The inclusion criteria were as follows:

- Having undergone at least two years of relevant sport participation;
- Capability for participation in the research, according to permission from the sport club, and personal consent.

Exclusion criteria were:

- Any history of acute or chronic low back pain;
- History of any surgical operations in the abdominal or lumbar area;
- To have suffered any recent sport injuries that prevented track practice for more than a day, or affected the athlete's full performance;
- Any acute respiratory problems (such as catching a cold) that inhibited regular exercising for more than a day, which may influence performance during the test.

Procedures: Initially, a pilot study was performed, in which the standard deviation (SD) of measurements and the intra-tester reliability of the examiner, i.e. the ultrasonographist, were obtained. The SD of the transversus abdominis (TA) thickness measurements was calculated to be 0.3 mm, and the examiner, had an intra class correlation (ICC) equal to 0.95 for a total of three measurements (Cronbach's alpha test, Table 1). The discrepancy (d) of sample results was considered to be as much as 0.2 mm, relative to the population. Based upon the relevant statistical formula, the sample size for a 95% confidence interval (CI; α=0.05) was estimated to be: $N= (Z_{1-\alpha/2})^2 \times SD^2/d^2$; $N= (1.96)^2 \times (0.3)^2/(0.2)^2 \approx 9$.

Table 1. Cronbach's alpha test, to determine intra-class correlation (Xn represents the times of testing)

	X1	X2	X3	X4
X1	1.000	0.995	0.994	0.994
X2	0.995	1.000	0.995	0.996
X3	0.994	0.995	1.000	0.998
X4	0.994	0.996	0.998	1.000

As a result, nine runners for each group (sprinting and distance running) were selected among volunteers, thus 18 athletes in total. A clinical US machine (Mitsubishi™, Japan) was used in this research to scan the morphology of left-side abdominal muscles. The machine was equipped with multiple probes, capable of emitting ultrasonic waves in different frequencies from 3.5 MHz up to 7.5 MHz. The latter was used in the present study as the output frequency, to obtain images of the muscles in question, through a curvilinear probe. Two standard points for US of the abdominal muscles, as mentioned in some previous studies (2,20) were utilized in this research as well. These are:

- Standard point for internal and external oblique abdominis (IOA and EOA), as well as for the TA: On the midclavicular line, half way between the inferior margin of the 10th rib and the superior margin of the iliac crest.
- Standard point for the rectus abdominis (RA): At 2 cm above and out of the umbilicus.

The above mentioned points were marked on the left side of each athlete's abdomen. All the athletes were positioned in supine on the examination table. The curvilinear probe of the US machine was placed on each standard point, while the athlete was advised not to move any part of his body throughout the procedure.

After obtaining the initial images on the screen, the athlete was informed to proceed with normal breathing, and to move just the tip of his index finger very slowly, as he reached the climax of the inhalation phase. Thus the examiner would know that the athlete has reached the end of the inhalation phase, and that the exhalation phase of breathing has commenced. At that given moment, the examiner froze the image, and registered the values of anteroposterior (AP) thickness of the relevant abdominal muscle. The procedure was exactly the same one used in in the preliminary, or pilot phase of the study. AP thicknesses of all abdominal muscles, including the RA, EOA and IOA, as well as the TA, were calculated by ultrasonographic scanning of both groups of runners' left abdomen at the aforementioned standard points.

Ethical considerations: The athletes were included in the study and examined, upon taking following ethical considerations into account:

- All the participants were informed of the exact procedures, and signed the written consent before the initiation of the study procedures.
- The sport club authorities were completely informed about the study, and allowed the athletes to participate in the study.
- None of the athletes' data was provided to any third party or the pertaining club. Only if the athletes requested their personal data, a copy was supplied to them.
- No expenses were imposed on the participants.

RESULTS

The results of study are summarized in Table 2. Since the Kolmogorov-Smirnov test validated normal distribution of the results, an independent t-test was applicated to the results in order to compare the two groups of athletes. As shown in the table, AP thicknesses of all abdominal muscles displayed statistically significant differences between the two groups. The RA, IOA and EOA muscles had larger AP thicknesses (p=0.01, p=0.001, p=0.000, respectively) among the sprinters, relative to the distance runners. In contrast, the AP thickness figure of the TA was higher (p=0.035) in the distance runners group, compared with the sprinters. Therefore, the mover and global muscles, such as the RA, had greater AP thickness among the sprinters. In contrast, the TA had a greater thickness in distance runners.

Table 2. Results of independent t-test on the runners' (n=18, df=16) abdominal muscles AP thicknesses (as means ± SD, in mm)

Muscle/Group	Sprinters	Distance runners	t-test
Rectus abdominis	13.5 ± 1.5	11.1 ± 0.7	t=4.47, p=0.01
Internal oblique	8.56 ± 1.43	6.37 ± 0.84	t=3.93, p=0.001
External oblique	10.2 ± 1.5	7.04 ± 0.06	t=6.06, p=0.000
Transversus abdominis	5.77 ± 1.42	7.35 ± 1.47	t=2.31, p=0.035

DISCUSSION

The results indicated that the AP thicknesses of all abdominal muscles had significant differences, among the two groups of the elite runners. The above given findings may suggest a potential relationship between the type of sport activity and the changes in the morphology of the muscles, even in those that are not primary movers in the particular activity. As expected, the speed and strength based running caused the more global muscles to gain a greater AP thicknesses, whereas endurance and distance type of running, which requires keeping a relatively low muscle force for longer duration, caused hypertrophy in the TA muscle.

One of the most important abdominal muscles, among others, is the TA. Its importance lies in its core stabilization role (2,5,7). Distance runners who have greater AP thicknesses should maintain a low velocity activity through a relatively long distance and duration of running. The TA, indeed, is not the prime mover muscle for running, as it is the duty of lower limb muscles to generate running locomotion. So this muscle seems to be in charge of keeping a suitable amount of force, required for postural stabilization, during lower limb motions (3,4,8,9). In this research, a significant difference was found between the two groups of runners, with greater thicknesses of TA in distance runners, indeed.

This result, may suggest that long term endurance running activity needs more stabilization in the trunk region; therefore, one could expect more activity from the trunk stabilizers. Increased activity in these muscles enhances their hypertrophy. This finding is in agreement with the results that Saunders, Rath and Hodges obtained (23), who found that during running speeds exceeding 3.0 m/s, the TA muscle does not reveal continuous tonical activities any more, and periods of TA inactivity exist. These inactivity periods may partly explain lower TA hypertrophy in sprinting athletes.

Although the exact relationship between the speed of trunk locomotion and TA muscle activity is not clear (24), it is evident that activity at higher speeds affects global muscles more than local and postural ones (3,16,24). This observation, together with those of Saunders et al (23), may suggest that higher speeds of running activity is associated with greater changes in the global muscles rather than the slower and postural ones. This can be considered as a special effect of exercise on muscles, including those without direct influence on the exercise (16). On the other hand, a study on EMG activity and the thickness of TA muscle has revealed positive relationship between these two parameters (20).

According to the above findings, an increase in muscle size may be associated with increased muscular activity, which is necessary for a local muscle as the TA to maintain its "fine tuning" function (19). The importance of such an increase in muscle size would be more prominent when muscle size decrease is developed in people with low back dysfunction and pain (11,13,14,22). In such circumstances, the TA and the lumbar multifidus muscles lose their coordination with the other low back area muscles, and become atrophied (11). This process of atrophy is accompanied by loss of the so called fine tuning function and postural adjustments (17,22).

The AP thicknesses of the RA and the EOA were greater in the sprinters. Sprinters have to use a "blast" of muscle energy in a short period of time to reach a very high speed. Previous studies confirmed that the global muscles display more activity during locomotions with higher speeds (23,24). Present findings comply with earlier studies, which demonstrated that global muscles like RA and EOA, have greater AP thicknesses in sprinters. Sprinters run at speeds of easily more than 3.0 m/s, which Saunders et al (23), refer to as the borderline speed, after which the pattern of muscular activity dominates the global muscles of the trunk. The reasons for this phenomenon can be diverse; but so far it is evident that at the higher speeds, the trunk undergoes more perturbations (9) that in turn should be compensated by more trunk muscle activity, which individuals with low back pain usually fail to develop (17).

The IOA muscle, however, has a different story. Some studies introduce it as a stabilizer (2). In contrast, some others consider the function of this muscle as identical to the global muscles (3,13). The reason for this difference is not clear yet, but seemingly the IOA and TA act similarly just during postural tasks (2), and not in tasks performed at higher speeds (3,24). If this is the case, current study findings again agree with previous studies in this concern, since increased hypertrophy of the IOA is observed in sprinters who perform their major activities at higher speeds. Perhaps, activities at higher speeds induce a shift of muscle function, from slow toward fast type functioning. This case has been previously reported (3).

In conclusion; although current study sheds light on some aspects of muscular morphologic changes, due to some kinds of sport activity, clearly more research is necessary to clarify the exact effects of different sorts of sports on the trunk muscles.

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