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PODSTAWY NEUROREHABILITACJI - UDAR MÓZGU - MODUŁ 2

Szkolenie obejmuje warsztaty praktyczne z zakresu diagnostyki funkcjonalnej pacjentów, podstawowych problemów strukturalnych i funkcjonalnych oraz propozycje terapii: reedukacji funkcji kończyny górnej i dolnej oraz wybranych strategii rehabilitacji. Omawiane jest również zagadnienie dysfagii, w tym objawy zaburzeń połykania, testy i ocena zaburzeń, zasady bezpiecznego karmienia, strategie terapeutyczne, ćwiczenia miofunkcyjne oraz specjalne techniki ułatwiające połykanie.

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Szkolenie skierowane do lekarzy ortopedów, pediatrów, lekarzy rodzinnych, lekarzy rehabilitacji medycznej, fizjoterapeutów oraz średniego personelu medycznego.

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Szkolenie obejmuje zagadnienia z anatomii, biomechaniki stawu skokowego i stopy, metodyki badania stopy, postępowania w leczeniu urazów stawu skokowego i stopy, nabytych zniekształceniach stopy (przyczyny, objawy, sposoby postępowania) oraz pozostałych dysfunkcjach w obrębie stawu skokowego i stopy (entezopatie, przeciążenia, zapalenia, zespoły uciskowe nerwów, gangliony, zmiany zwyrodnieniowe, stopa cukrzycowa, stopa reumatoidalna).

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Szkolenie skierowane do lekarzy ortopedów, pediatrów, lekarzy rodzinnych, lekarzy rehabilitacji medycznej, fizjoterapeutów oraz średniego personelu medycznego.

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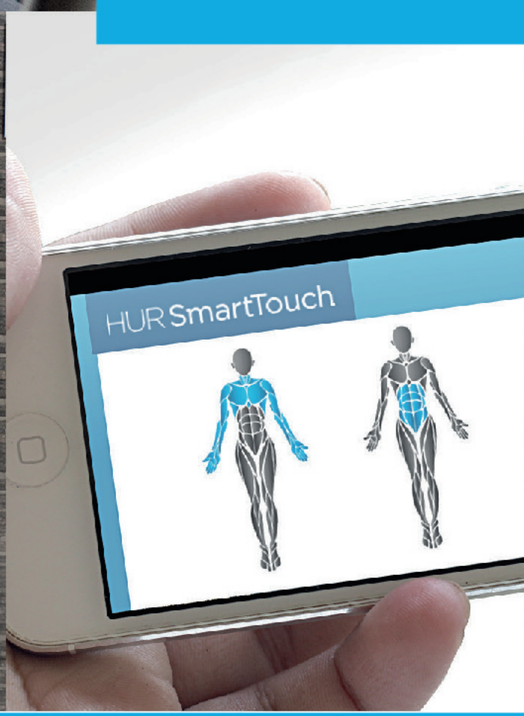

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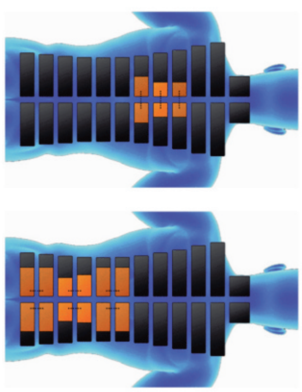

StimaWELL®120MTRS to wysokiej jakości dynamiczny system terapii pleców i kręgosłupa, który został zaprojektowany z wykorzystaniem najnowszych osiągnięć technologicznych w tej dziedzinie. Dwunastokanałowa mata StimaWELL®120MTRS umożliwia teraz pacjentowi wielowymiarowy system leczenia kręgosłupa, każdy zabieg trwa od 20 do 30 minut i jest naprawdę skuteczny. Szczególne znaczenie ma fakt, iż urządzenie to zostało wyposażone w doceniony na niemieckim rynku elektrostymulator StimaWELL® pracujący w zakresie niskich i średnich modulowanych częstotliwości w zakresie od 0 do 100Hz i 2000 do 6000Hz (prąd dwufazowy, symetryczny, prostokątny), które z łatwością pokonują barierę skóry i docierają do najgłębszych warstw mięśni. System został zaprojektowany głównie do terapii bólu, terapii mięśniowej i masażu (4 w 1). Twój pacjent skorzysta ze zwiększonego zakresu opcji, które możesz mu teraz zaoferować! Dodatkowo, należy wiedzieć, że mata została wyposażona w 24 elektrody, który są podgrzewane do 40°C.

System StimaWELL®120MTRS zapewnia kompleksowy pakiet do profilaktyki i leczenia ostrych i przewlekłych chorób pleców. Mata wyposażona jest w szeroki wachlarz możliwości programowania w zależności od modulacji i ustawień uruchamiamy terapię bólu, budowę mięśni, relaksację mięśni, a także różnego rodzaje masaże, takie jak stukanie, gładzenie i ugniatanie. Opatentowana technolgia StimaWELL®120MTRS to dla pacjenta skuteczny, głęboko relaksujący system terapii. Dwie z wielu zalet stymulacji średniej częstotliwości w porównaniu z innymi typami to osiągnięcie wysokiego poziomu kompatybilności pacjentów i kojące uczucie, generowane przez przepływ prądu elektrycznego. Ten proces aktywuje silne skurcze mięśniowe i zapewnia większe obszary leczenia. Zastosowanie średniej częstotliwości w systemie StimaWELL®120MTRS, występującej w zakresie od 2000 do 6000 Hz, impulsy łatwiej pokonują aspekt oporu skóry niż prądy w dolnych zakresach częstotliwości. Oznacza to, że dla pacjenta terapia oparta na przepływie prądu elektrycznego w średnim zakresie częstotliwości jest często doświadczana jako szczególnie przyjemna, a nie drażniąca. System StimaWELL®120MTRS jest niezwykle łatwy w obsłudze i nie wymaga specjalnej preparacji. Sterowanie za pośrednictwem intuicyjnego ekranu dotykowego jest proste i czytelne. Programy można szybko wybrać i jeśli to konieczne, dopasować do konkretnych potrzeb Twojego pacjenta. Dzięki nowemu trybowi automatycznego wyboru programów opartych na wskazaniach przy użyciu diagnozy – kalibracji, użytkownik ma możliwość automatycznego wyboru odpowiedniego programu terapeutycznego zgodnie z danymi anamnestrującymi, które mogą być stosowane w każdej sesji terapeutycznej. Twój pacjent jest w stanie kontrolować poziom prądu elektrycznego za pomocą pilota zdalnego sterowania.

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Zastosowanie fizjoterapeutycznego obrazowania ultrasonograficznego i sonofeedbacku w ocenie aktywności mięśnia poprzecznego brzucha

The use of Rehabilitative Ultrasound Imaging (RUSI) and sonofeedback in the assessment of the activity of transversus abdominis muscle

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Streszczenie

Cel. Celem badań była ocena grubości i symetrii mięśnia poprzecznego brzucha (TrA) z wykorzystaniem obrazowania ultrasonograficznego w rehabilitacji oraz ocena efektywności sonofeedbacku w nauczaniu i kontroli aktywności mięśnia TrA.
Materiał i metody. W badaniu wzięło udział 28 zdrowych osób (17 kobiet i 11 mężczyzn) w wieku od 19 do 22 lat (średnia 21 ± 1,08 lat). Badani poddani zostali badaniu RUSI oceniającemu grubość mięśnia TrA w spoczynku oraz podczas aktywności. Na podstawie uzyskanych pomiarów obliczono Współczynnik Aktywacji Mięśnia oraz Procent Zmiany Grubości Mięśnia.
Wyniki. Średnia grubość TrA w spoczynku wyniosła 3,19 mm wśród kobiet i 4,37 mm wśród mężczyzn. Podczas kontrolowanej aktywacji grubość mięśnia TrA zwiększyła się o 69% po stronie prawej i 64% po stronie lewej u kobiet oraz odpowiednio o 70% i 64% wśród mężczyzn. W podgrupie mężczyzn wykazano istotną statystycznie różnicę w grubości TrA po stronie lewej i prawej. Pod kontrolą sonofeedbacku aktywność TrA była istotnie statystycznie większa niż podczas skurczu izometrycznego bez kontroli sonofeedbacku. Aktywność TrA w podgrupie osób z bólem kręgosłupa była niższa i wynosiła 64%, podczas gdy w grupie osób nie zgłaszających dolegliwości wynosiła 72%.
Wnioski.
1. RUSI stanowi skuteczną metodę oceny budowy i aktywności mięśnia poprzecznego brzucha w spoczynku i podczas kontrolowanej aktywacji;
2. Zmniejszenie grubości i aktywności TrA związane jest z występowaniem dolegliwości bólowych w odcinku lędźwiowym kręgosłupa;
3. Zastosowanie sonofeedbacku umożliwia istotne statystycznie zwiększenie stopnia aktywacji i wyrównanie asymetrii mięśnia poprzecznego brzucha.

Słowa kluczowe:
Rehabilitative Ultrasound Imaging, RUSI, diagnostyka funkcjonalna. Mięsień poprzeczny brzucha, aktywność mięśniowa

Abstract

Purpose. The purpose of the study was to evaluate thickness and symmetry of Transversus Abdominis muscle (TrA) during rest and activation with the use of Rehabilitative Ultrasound Imaging (RUSI) and the assessment of sonofeedback effectivness in learning and control of TrA activity.
Material and methods. The study was conducted on 28 healthy subjects (17 women and i 11 men) aged 19-22 years (mean 21±1,08 years). The subjects undergone RUSI assessment considering thickness of TrA in rest and during contraction. Basing on results the Activation Ration and Percent of Muscle Change were calculated.
Results. Mean thickness of TrA in rest was 3,19 mm among women and 4,37 mm among men. During controlled activity thickness of TrA increased by 69% on right side and by 64% on left side and respectively by 70% and 64% among men. The results showed a significant difference in TrA thickness between right and left side at rest and during contraction among men. During sonofeedback recorded thickness of TrA was significantly higher comparing to results without control of sonofeedback. TrA activity was lower in the group with low back pain and it was 64%, while in pain-free group the activity was 72%.
Conclusions.
1. RUSI is an effective method to evaluate the morphology and activity of the Transversus Abdominis muscle at rest and during controlled activation;
2. The decrease in thickness and activity impairment of TrA is related to the occurrence of low back pain;
3. The use of sonofeedback enables significant improvement in activation and equalization of TrA asymmetry.

Key words:
Rehabilitative Ultrasound Imaging, RUSI, functional diagnostic, transversus abdominis, muscle activity

Introduction

Transversus abdominis muscle (TrA) has for several years been one of the most ‘popular’ muscle in our body. Much has been said about its role in building muscle corset and core stabilization [1, 2]. Nevertheless, over time, opinions on its function have become increasingly diverse and controversial [3]. The fact is, that many further imagining and functional studies are needed to thoroughly understand the function of TrA. One of the most objective methods, that can be used in scientific research, as well as in physiotherapy practice, is Rehabilitative Ultrasound Imaging (RUSI). In present study, the current knowledge about TrA and the use of RUSI in its examination and therapy has been explained.

Anatomy and physiology of TrA

TrA is located in the deepest layer of all abdominal muscles. In the contrary to external oblique muscle (EO), which covers external surface of lower ribs, and internal oblique muscle (IO) which is attached to the edges of lower ribs, TrA origins on internal surface of 6 lower rib cartilages. Its insertions runs between the origins of diaphragm, that is why it participates in the movements of the chest. Subsequently, the fibres run along the connection of thoraco-lumbar fascia (TLF), anterior two thirds of interior iliac crest and lateral half of inguinal ligament [4], parallelly and transversely to semilunar line. Upper part of TrA (fibers which take origin from the surface of seventh and eighth rib) is completely covered by rectus abdominis (RA), below, the semilunar line runs laterally from this muscle. In semilunar line the muscle fibres form aponeurosis of RA and linea alba sheath [4]. From interior side TrA builds up all lateral side of the abdomen, which can functionally be divided to: upper part (above 11th rib cartilage), medial (between 11th cartilage and iliac crest) and lower (below iliac crest) [5]. The origins and morphology of the muscle make it functionally associated with the movements of the chest, hips, and spine.

TrA studies support its potential involvement in the control of the lumbar-pelvic complex [6, 7, 8]. Bilateral activation of TrA causes transferring the tension to the fascial structures of the lumbar region, including thoraco-lumbar fascia, modulation of the intra-abdominal pressure (IAP) [6, 7] and compression of sacroiliac joint [8]. Middle fibers of TrA attach to TLF, that is why its bilateral activation transmit the tension to lumbar part of the spine [1]. The myofascial unit formed by TrA and TLF is described as deep muscles corset [2].

Intervertebral control of lumbar spine can be also augmented by increasing IAP. It was shown that an increase in IAP leads to decreased intervertebral mobility and increased spine rigidity [6]. The arrangement of medial fibres of TrA around the abdominal cavity gives this part has the greatest potential for modulation of the IAP [5]. EMG research confirmed that the activation of medial part of TrA has a greater influence on IAP than activation of other abdominal muscles [9], and that muscle fibres of this region have the lowest activation treshold during the respiration process [5]. Fibres of lower and upper part of TrA can also participate in the modulation of IAP [10].

The basic function of lower part of TrA is to is to maintain statics of abdominal organs while standing position. Mięśnie tej części odpowiedzialne są również za kompresję stawu krzyżowo-biodrowego i uczestniczą w stabilizacji tych stawów poprzez mechanizm zamknięcia siłowego opisanego przez Snijders i wsp. [11]. Studies in vivo conducted by Richardson et al. confirmed pre-activation of TrA during consious abdominal drawing-in maneuver (ADIM) as well increase of rigidity, and thus stabilization of sacroiliac joint among healthy subjects [8]. ADIM is the basic exercise of motor control and conscious activation of TrA used in training. It has been shown that TrA is preferentially activated in this exercise, prior to the contraction of more superficial abdominal muscles [12, 13], and that TrA activation precedes planned limb movement or spinal loading [14, 15, 13].

The role of TRA in postural control was confirmed in Reeve and Dilley's studies, which show that while maintaining a normal posture, the TrA thickness is statistically significantly greater than when during sway back. Similarly, while comparing normal sitting to slouched sitting [16].

Considering the relative thickness of the abdominal muscles, TrA is the thinnest muscle, in contrast RA, which is the thickest [17]. Thickness of TrA and IO increases during expiration, as both these muscles are auxiliary expiratory muscles [18, 19, 20]. The thickness of the abdominal muscles is not evenly distributed throughout the abdominal wall. In the upper part of the abdomen, the muscles are usually the thickest, while the lower part is the thinnest. Sometimes TrA and internal oblique muscle fibres disappear below the hip crest [5].

Based on the absolute values of muscle thickness, men have statistically thicker abdominal muscles than women [13, 17, 21]. However, in relation to body weight, TrA represents a greater proportion of total thickness of posterior abdominal muscles, both at rest and during activation, in women than in men [13, 17]. According to Rankin at all. [17] thickness of TrA decreases with age, however regular exercises can prevent its atrophy [10].

Considering the contribution of TrA in central stabilization, it may be assumed that impaired motor control may cause lumbar spine pain, including nonspecific back pain syndromes (NSBPS), as confirmed by many scientific reports [8, 10, 22]. Research conducted by Marshall and Murphy demonstrated the lack of feed-forward activation for TrA prior to rapid limb movement in subjects with low back pain [23].

Assymetry of TrA was found in subjects with mild adolescent idiopatic scoliosis [24, 25]. The authors noticed that the more the lumbar Cobb's angle to the right, the thicker the right TrA compared to the left TrA during abdominal drawing-in maneuver (ADIM) [26].

Chmielewska et al. suggested also the role of TrA in the functioning of pelvic floor muscles and indicate that its abnormal activity may be related to urinary incontinence [27]. Changes in TrA function have a direct effect on pelvic floor muscles function, because the contraction of TrA causes co-contraction of pelvic floor muscles [28], including muscle levator ani [29]. Due to the function of lower part of TrA associated with the support of internal organs [10], it can be assumed that its weakness may contribute to the lowering of the of the organs of urogenital system. A review of the literature done by Bø et al. shows that the views of researchers on the synergistic effect of TrA on pelvic floor muscles are consistent. There is evidence that coactivation of pelvic floor muscles and TrA is altered or does not exist at all in women with urinary incontinence [30].

Rehabilitative Ultrasound Imaging (RUSI)

Several methods are used to examine abdominal muscles, e.g. ultrasonography (USG), electromyography (EMG) or functional magnetic resonance imaging (fRM). Electromyography (EMG) is a commonly used method for assessing muscle function, but its invasiveness excludes the use of this method in physiotherapeutic practice. The use of superficial EMG is limited due to the difficulty in selecting TrA activity and distinguishing it from the activity of the IO muscle.

RUSI is a non-invasive procedure that allows evaluation of the morphology and function of muscles in a qualitative and quantitative manner in a real time. It can be used as a diagnostic tool as well as in clinical practice during rehabilitation process. RUSI was compared as an evaluation tool of TrA morphology with magnetic resonance and as an indicator of muscle function with electromyography. Irrespectively of the tested population, it showed high sensitivity and precision [20, 31, 32, 33, 43].

During RUSI examination the focus is put mainly on thickness and the symmetry of TrA, at the rest and during the contraction. The sequence of abdominal muscle activation during rest and during voluntary movements. RUSI enables imagining of TrA in lying, standing or sitting position as well as during exercises.

During normal activation TrA increases its diameter and causes tension of abdominal muscles fascia. In the correct pattern of muscle activity the dimension of EO and IO muscles remain constant [34].

Sonofeedback (SF)

Deep muscles, exemplified by TrA, are tonic stabilizing muscles located deep in the body, only to some extend depended on our will. Patients are often not aware of how to activate those muscles which makes the conscious contraction very difficult for them. The use of sonofeedback enables imaging of deep muscles during exercises and controlling the contraction by patients themselves. By many authors sonofeedback is considered to be an effective method supporting the process of teaching activation and controlling the activity of stabilizing muscles [35, 36].

Purpose

The purpose of this study was to evaluate the thickness and symmetry of TrA by measuring the thickness of the muscle in rest and during contraction using RUSI, considering the physical activity level and the occurence of low back pain, as well as the assessment of the effectiveness of sonofeedback in the teaching and motor control of TrA.

Material and methods

The study was conducted among 28 randomly selected healthy students of Physiotherapy Faculty, Medical University in Lodz, 17 women and 11 men, aged 19-22 years. All participants signed the informed consent. The exclusion criteria were: lack of consent, surgical procedures on abdominal cavity, chest, pelvic girdle or spine, respiratory and cardiovascular system disorders, immobilization (>14 days) resulting from disease or injury during the year prior the study, use of drugs influencing activity of neuromuscular system. The participants were asked to fill a questionnaire considering demographic data, level of physical activity and occurrence of low back pain. Subsequently the subjects undergone RUSI examination assessing TrA thickness in rest and during contraction. Basing on results the Activation Ration and Percent of Muscle Change were calculated.

Results were analyzed in terms of sex, level of physical activity and occurrence of low back pain. For statistical analysis MS EXCEL Analysis ToolPak was used.

Procedure of examination

RUSI images were obtained with the use of HONDA ELECTRONICS HS-2200W scanner with a linear array transducer, frequency 8,5 MHz. During the examination subjects remain in supine rest position with legs bent in hip and knee joints and arms along the body. This position is supposed to ensure the relaxation of superficial muscles [12, 13].

The transducer was placed on the anterolateral wall of the abdomen, in the middle of TrA, between the iliac crest and the 11th rib edge. The middle part of TrA is the most commonly chosen site of RUSI because of good visibility of muscle boundaries, ease of identification of individual muscle and clarity of thickness changes during contraction. Results obtained can be therefore easily compared with other authors. The transducer was placed perpendicular to the longitudinal axis of the body, in the anterior axillary line [10]. This way the image of the cross-section of 3 muscles of anteriolateral abdominal wall (EO, IO, TrA) was obtained. TrA is the deepest muscle of the three.

Measurement of TrA thickness was performed at the widest point, by guiding the perpendicular line between the upper border of the lower fascia and the lower border of the upper fascia, visible as two hyperechogenic clear lines. Separate measurements were made for the left and right sides. Thickness of TrA at rest was taken in the finish point of normal exhalation while thickness during contraction – during ADIM.

In order to perform ADIM subjects were asked to inhale and exhale normally and at the end of exhalation to contract TrA by bringing their belly button up and in towards their spine, without moving the spine and keeping superficial muscles as much relaxed as possible. Subject could repeat the exercise twice to get best results.

The results were then used to calculate activation index (equation 1) and muscle percent change (equation 2) [37, 38].

$$\text{Activation Index} = \frac{\text{muscle during ADIM}}{\text{muscle at rest}} \quad (1)$$

$$\text{Muscle percent change} = \frac{\text{muscle during ADIM - muscle at rest}}{\text{muscle at rest}} \quad (2)$$

Methodology of sonofeedback
Transducer was placed in the same site as while examination of the TrA. Subjects remained in the same position and could observe their muscles on the screen, which was placed in front so they do not have to rotate the head. By controlling the TrA activity on screen subjects were asked to perform ADIM.

Statistical Analysis
Statistical analysis was performed using MS EXCEL 2016 Anylysis ToolPak. The results are presented as mean values with the ±SD and 95% confidence interval. The threshold of the p value considered as significant was set at $p < 0.05$. The differences between groups for each parameter were identified using the t test.

Results

28 randomly chosen students of Physiotherapy Faculty, Medical University in Lodz, 17 women and 11 men, aged 19-22 years (mean age 21 years) were included in the study. Most of the subjects declared systematic physical activity, at leat 1-2 times a week. Mean time of exercising per week was 5 hours. Prefered forms of physical activity (in order of the most common) were: swimming, gym and jogging. 59% of subjects assessed their level of physical fitness as good, 12% as very good and 29% as average. 18 subjects declared occurence of low back pain.

Mean values ± SD of TrA thickness in rest and during contraction (ADIM) are presented in table 1.

Table 1. Mean values ± SD of TrA thickness in rest and during contraction (ADIM) in men and women

TrA	Women (n=17)				Men (n=11)				W/M
	Right side	Left side	Mean	P value	Right side	Left side	Mean	P value	P value
At rest (mm)	3.16 ± 0.58	3.22 ± 0.55	3.19 ± 0.42	0.38	4.7 ± 1.42	4.05 ± 0.99	4.37 ± 1.19	**0.002***	**0.005***
ADIM (mm)	5.24 ± 1.66	5.21 ± 1.36	5.23 ± 1.40	0.46	7.77 ± 2.29	6.61 ± 2.37	7.19 ± 2.26	**0.003***	**0.01***
ADIM-SF (mm)	6.13 ± 1.64	6.31 ± 1.67	6.22 ± 1.56	0.24	9.21 ± 2.65	8.33 ± 2.54	8.77 ± 2.50	**0.04***	**0.005***
AI	1.69 ± 0.54	1.64 ± 0.46	1.67 ± 044	----------	1.70 ± 0.42	1.64 ± 0.50	1.67 ± 0.45	-----------	------------
AI-SF	1.98 ± 0.56	1.99 ± 0.54	1.99 ± 0.51	----------	2.01 ± 0.46	2.07 ± 0.56	2.04 ± 0.47	------------	------------
%	69%	64%	67%	----------	70%	64%	67%	------------	------------
% SF	98%	99%	99%	----------	101%	107%	104%	------------	------------

Skróty: SD – Odchylenie Standardowe, TrA – Mięsień Poprzeczny Brzucha, ADIM – Manewr Wciągania Brzucha, SF –Sonofeedback, AI – Współczynnik Aktywacji TrA, AI-SF – Współczynnik Aktywacji TrA podczas sonofeedbacku, % - Procent Aktywacji TrA, %SF - Procent Aktywacji TrA podczas sonofeedbacku.
* p < 0,05
Abbreviations: SD – Standard Deviation, TrA – Transversus Abdominis, ADIM – Abdominal Muscle-In Maneuver, SF –Sonofeedback, AI – Activation Index, AI-SF – Activation Index during Sonofeedback, % - Muscle Percent Change, %SF - Muscle Percent Change during Sonofeedback.
* p < 0.05.

The study showed that the mean thickness of TrA in rest was 3,19 ±0,42 mm among women and 4,37±1,19 among men, and during contraction respectively: 7,19±2,26 mm and 5,23 ±1,40 mm. TrA thickness at rest and during activation was higher among men than among women (the difference was respectively: 1,18 mm and 1,93 mm).

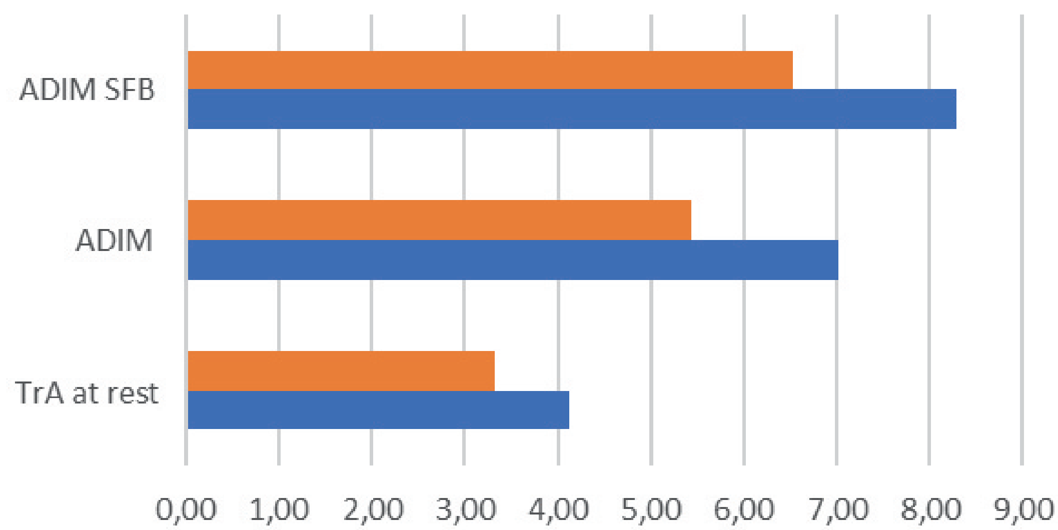
During contraction the thickness of TrA increased by 2,08 mm (69%) on the right side and by 1,99 mm (64%) on the left side among women and respectively by 3,08 mm (70%) and 2,55 mm (64%) among men.

The results showed a significant difference in TrA thickness between right and left side at rest and during contraction among men. At rest the difference between sides was 0,65 (p=0,002) and during contraction: 1,16 mm (p=0,003).

During sonofeedback recorded thickness of TrA increased by 2,96 mm (p=0,0001) on the right side and by 3,09 mm (p=0,0003) on the left side among women and by 4,51 mm on the right side (p=0,003) and by 4,28 mm on the left side

(p=0,0004) among men comparing to results without control of sonofeedback.
Activation of TrA presented by Activation Index and Muscle Percent Change was significantly higher during sonofeedback control than without it. Mean Muscle Percent Change during sonofeedback among women was 99% and among men: 104%. The difference in Muscle Percent Change with and without sonofeedback was 27,9% (0,0001) on the right side and 34,2% (p=0,0003) on the left side among women and 31,5% (0,001) and 42% (0,0001) among men.
There was no statistically significant difference in the Activation Index and Muscle Percent Change of TrA between women and men, at rest as well as during contraction.

TrA thickness and low back pain
As many as 61% of the respondents reported the occurrence of pain in the lumbar spine. Low back pain occured more commonly among women (70%) (n=12/17) than among men (45%) (n=5/11). There was a statistically significant lower thickness of TrA at both rest (p = 0.03) and during contraction (p = 0.05) compared to those who reported no symptoms (p = 0.03) The results are shown in Diagram 1.



	TrA at rest	ADIM	ADIM SFB
LBP	3,32	5,44	6,53
NO LBP	4,12	7,01	8,29

Fig 1. Comparison of TrA thickness among subjects with low back pain and without low back pain.
ADIM – Abdominal Muscle-In Maneuver, SF –Sonofeedback, LBP – Low back pain, NO LBP – No low back pain

TrA activity, expressed as a percent muscle change, was lower in the group of subjects with low back pain and it was 64%, while in pain-free group the activity was 72%.

Discussion

Ultrasound imaging is a method commonly used in medicine. This is a safe, inexpensive and readily available technique for examining many organs and tissues. The possibility of non-invasive, objective evaluation of deep anatomical structures such as muscles, joints, ligaments or bursae, is an undisputed advantage of ultrasonography, confirming the need for utilizing this method in functional physiotherapy diagnostics. Ultrasound imaging is a method that allows physiotherapist to make functional diagnosis in order to properly plan the therapeutic process and to exclude possible contraindications. There are many reports confirming the reliability of RUSI in the assessment of TrA muscle morphology (32, 20, 33, 43).

In addition to the diagnostic value, RUSI enables a real time movement observation, providing both the therapist and the patient with the necessary feedback. Especially considering structures such as TrA, which activity is difficult to initiate and to assess visually or by palpation. A number of studies have confirmed the increase in activity of deep muscles – TrA, EO, IO or multifidus muscle, with sonofeedback (36, 35). Nevertheless, some others are doubtful (12). Hence, there is the need to continue research on the use of RUSI in physiotherapeutic practice, which will provide clear scientific evidence on the effectiveness and applicability of this method.

The purpose of this study was to evaluate the thickness and symmetry of TrA in regards to occurrence of low back pain (LBP) as well as to evaluate the efficacy of sonofeedback in learning and control of abdominal muscle activity. Taking into account the number of disorders that result in abnormal (delayed, asymmetric or decreased) activation of the TrA muscle, training of this muscle is considered to be an important component of the rehabilitation process for patients with LBP (39, 8), scoliosis (40), incontinence (30), as well as in improving the autonomy and performance of daily activities in the elderly (41).

According to this research, the LBP affects as many as 60% of students. This is an astonishing number, especially given the young age and the active lifestyle of the respondents. It was demonstrated, that in the group of people with LBP, the thickness of TrA was significantly decreased at rest and during the contraction. The impaired activation ability was also noted (Percent of Muscle Change was by 8% lower among subjects declaring LBP). The results, thus, confirmed the relationship between the occurrence of pain and the reduction of the thickness of the TrA muscle, which may suggest reduced spinal stabilization due to weakness of TrA (42).

The analysis of results in LBP group no asymmetry between right and left TrA muscle was found, but interestingly, it was found in a significant extend while analyzing results of men.

The observed asymmetry between right and left TrA was significant and reached 18% in rest and the same during contraction. As reported by Rankin et al., in healthy individuals without dysfunction in the lumbar region, there may be differences in the thickness of the muscles of posterior abdominal wall, ranging from 12,5 to 24% (17), the asymmetry found in this research can be considered as normal. However, most studies show that the asymmetry should be maintained, irrespectively of lateralization or daily activities (13, 43). There is a potential possibility of the asymmetry to occur among subjects practicing repeatable asymmetric movements (recreational and occupational factors) or among subjects with changes in musculoskeletal system (scoliosis, difference between lower extremities, asymmetry of the pelvis) (2). Unfortunately this study did not cover posture assessment, that is why it is impossible to state if this asymmetry was connected to existence of other impairments in musculoskeletal system.

The use of sonofeedback significantly improved the activation of TrA. By controlling muscle contraction on the screen subjects increased the thickness of TrA during contraction by 16% among women and 18% among men. It should also be noted that in the group of men the weaker TrA not only equalized its activity but even exceeded by 6% the activity of the right TrA by sonofeedback control. The difference was statically significant (p=0.001). This fact confirms the hypothesis that sonofeedback enables conscious increase in the recruitment of muscle units and the equalization of the activation degree between the two sides.

The limitation of this study was the lack of in the body posture assessment, which would make it possible to determine whether the asymmetry of TrA activity was associated with asymmetry of the spine. Future studies should also investigate more thoroughly the type of physical activity, because it may also affect TrA activity. All participants in the study were physiotherapy students, that is why they had at least basic knowledge about the anatomy and function of the deep muscles. It is possible that the results will differ among subjects not related to medical sciences and sport. It is also interesting to compare the function of deep muscles in people professionally practicing sport and those with sedentary lifestyle, as well as in other groups. A curious fact observed during this study was that the best results of TrA thickness and activity was obtained by a chorus singer, with no regular physical activity. This observation which may be due to the associated function of the TrA and the diaphragm, which was mentioned in the introduction.

Obtained results confirmed the effectiveness of RUSI in assessment of TrA activity and the relationship between impaired function of this muscle and occurrence of low back pain. Therefore, it is suggested to conduct further studies on symmetry and activity of deep muscles as well to include RUSI in prevention of low back pain and postural defects.

Scientific reports confirm the role of deep abdominal muscles in the function of motor system. The review of the literature conducted by Dyczewska-Wójtowicz in 2016 showed disturbance of timing of deep muscle activation in children with lower back pain. It has been shown that the initial activation during movement is started by superficial muscles of the torso, only then the deep local stabilizers engage. Changing roles between muscle groups can be a source of overload problems (46). Therefore the physiotherapist should have access to tools that allow accurate assessment of their morphology and function. RUSI is a new tool that potential is related to increasing diagnostic capabilities in clinical practice and in the evidence based practice of deep muscle function. RUSI can be an excellent preventive tool for detecting early functional changes or asymmetries, so that early treatment and prevention of severe musculoskeletal system disorders would be possible.

Conclusions

1. RUSI is an effective method to evaluate the morphology and activity of the Transversus Abdominis muscle at rest and during contraction;
2. The decrease in thickness and activity impairment of TrA is related to the occurrence of low back pain;
3. The use of sonofeedback enables significant improvement in activation and equalization of TrA asymmetry during time of the procedure.

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