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Original article

# Assessment of the abdominal muscles at rest and during abdominal drawing-in manoeuvre in adolescent physically active girls: A case–control study

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#### Abstract

*Background*: An impact of regular physical activity (RPA) on the abdominal muscles may be significant when comparing various symptomatic groups. However, there is lack comprehensive information in this field. The objective of this study was to assess the lateral abdominal wall at rest and during abdominal drawing-in manoeuvre in adolescent physically active girls in different body positions.

*Methods*: One hundred and forty-four female students, 13–17 years of age, participated in the study. Participants were divided into 2 groups based on a physical activity (PA) statement. Measurements of the thickness of the abdominal muscles at rest and during abdominal drawing-in manoeuvre were made in the supine and standing positions by ultrasound imaging.

*Results*: Compared to the control group, activities of the obliquus internus and transversus abdominis muscles were higher in the regular PA group by 8.9% (95%CI: 3.1–14.7) and 36% (95%CI: 19.1–47.5), respectively. In the RPA group, the transversus abdominis preferential activation ratio was greater by 0.03 (95%CI: 0.01–0.04), and the contraction ratio was greater by a mean value of 0.35 (95%CI: 0.18–0.46).

*Conclusion*: RPA does not have any effect on the resting thickness of the abdominal muscles in the supine and standing positions. Girls performing RPA have a greater ability to perform an independent activation and greater contractions of the transversus abdominis.

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Keywords: External oblique abdominis; Internal oblique abdominis; Physical activity; Transversus abdominis; Ultrasound

#### 1. Introduction

The lateral wall of the abdomen is built of the transversal abdominal (TrA), abdominal oblique internal (OI), and abdominal oblique external (OE) muscle. Of these abdominal muscles, the greatest role is ascribed to the TrA, which, together with the posterior portion of the OI, is part of a deep cylinder providing stability for the lumbar spine.<sup>1,2</sup> Involuntary action of these muscles is associated with the protective lumbar spine mechanism,<sup>3</sup> which is disturbed in adults with low back pain (LBP).<sup>4,5</sup> Currently, imaging ultrasonography (USI), a reliable and valid technique, most often used by therapists and investigators, is employed for the evaluation of structure, function, and activities of the abdominal muscles.<sup>6,7</sup> The measurements

obtained by USI are similar to those obtained by magnetic resonance imaging and correlate well with electromyography.<sup>8,9</sup>

A potentially important role of the abdominal muscle in the stabilisation of the lumbar spine made many researchers analyse the characteristics of these muscles in healthy and LBP population.<sup>4,10–15</sup> In these reports, in addition to the evaluation of the muscle thickness at rest, the authors studied the activity of the abdominal muscles during the "abdominal drawing-in manoeuvre" (ADIM), which is used to evaluate the TrA function.<sup>7</sup> Moreover, the researchers evaluated possible effects of sex, age, height, body weight, body mass index (BMI), and hand dominance in search for variables that can affect the USI of the abdominal muscles at rest and during ADIM.<sup>10,13,16</sup> However, in studies of the adult population, in professional cricket players, the TrA and OI are thicker than in the normal population.<sup>8</sup> Thus, the effect of physical activity (PA) on the abdominal muscles may be significant when comparing various symptomatic groups. However, we do not have full information

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on this subject. The results for the TrA contraction ratio (TrA during ADIM/TrA at rest) are also somewhat inconsistent because in some studies of healthy adults, this factor is approximately 1.5,<sup>10,17</sup> and in others 1.8.<sup>16</sup> In these studies, the authors did not provide the level of PA of the persons studied; however, all participants in the study of Springer et al.<sup>16</sup> were from the department of defence, and probably their level of PA was greater than average. This may explain the differences in the results.

Recently, Linek et al.<sup>18</sup> indicated lower thickness of the TrA, OI, and OE on both sides of the body in children and adolescents with scoliosis. The mean values of the abdominal muscle thickness obtained in other studies in scoliosis patients do not seem to confirm it.<sup>19</sup> The easiest way to explain such difference in the thickness of the abdominal muscles is the different types and severity of scoliosis in both mentioned studies. However, it also may be that in the paper by Linek et al.,<sup>18</sup> the population free of scoliosis (control group) was more physically active than population with scoliosis, and this may explain the difference in muscle thickness at rest between the control and experimental groups, as was observed in professional cricket players.<sup>8</sup> Taking into consideration a growing interest in abdominal muscles in children and adolescents, at this state of the studies, in addition to the assessment of the height, body mass, or BMI on the thickness of the abdominal muscles,<sup>20</sup> it is necessary to evaluate the effect of regular PA (RPA) on the OE, OI, and TrA at rest and during ADIM in adolescents. Such information will allow more controlled planning of future studies on adolescents.

The studies to date demonstrate that women also activate the TrA much better during ADIM,<sup>10</sup> which points to a greater role of this muscle in motor control in women.<sup>10,16</sup> The studies also clearly show that adolescent girls are more sensitive to LBP<sup>21,22</sup> and scoliosis.<sup>23</sup> Thus, abnormalities in the TrA can have a greater effect on the condition of the musculoskeletal system in females. Longitudinal studies clearly demonstrate that in female athletes, with improper motor control of the trunk, the incidence of knee injuries is higher.<sup>24,25</sup> Hides and Stanton<sup>26</sup> pointed out a possible negative impact of sports on the TrA. Thus, taking into consideration a greater role of TrA in females and the possible negative effect of sports on its characteristics, the authors attempted to determine the effect of RPA on the characteristics of the muscles of the lateral wall of the abdomen in teenage girls at rest and during ADIM and in different body positions (supine, standing).

### 2. Methods

#### 2.1. Participants

A total of 144 female students of middle school and subsequent levels, 13–17 years of age, participated in the study. Prior to qualifying an individual for the study, a preliminary selection was performed, during which body posture was evaluated and a short medical history of a given person was taken. Thus, in each individual, external signs of scoliosis were evaluated and/or other abnormalities in body posture. For this purpose, Adams' test was performed and a scoliometer was used for the evaluation of the body rotation. Adams' test and a scoliometer are

widely used for the evaluation of body rotation and scoliosis, as well as in clinical studies on children with scoliosis.<sup>27,28</sup> The intra-rater reliability of axial trunk rotation measures measured by the scoliometer was very good and excellent for the upper, medium, and lower thorax and lumbar segments.<sup>29</sup> Based on this examination, only the subjects in whom no body rotation angle was detected (the acceptable range of trunk rotation measured with the scoliometer was between  $0^{\circ}$  and  $3^{\circ}$ ) were included. Moreover, based on an interview, the following girls were excluded: (a) in whom any surgical procedure was performed in the chest, the abdominal cavity, the pelvic girdle, and/or the spine; (b) with chronic cardiovascular/respiratory system disease; (c) who experienced an illness and/or trauma that was associated with a prolonged (>14 days) hospitalisation or immobilisation during a period of 2 years prior to the study; (d) who experienced pain in the spine, pelvic girdle or lower limbs during 3 months preceding the study; (e) who took medications that may affect the function of the nervous and muscular systems within 1 year preceding the study.

Finally, each subject responded to questions about current and past PAs. This was the basis for dividing subjects into 2 groups. The individuals who currently do not perform RPA were included in the first (control) group (n = 74). The individuals who stated that they belonged to a sport club, and therefore regularly practice a specific sport discipline or activity, were included in the second group (RPA group, n = 70). A statement that a person has regularly been performing RPA for at least 2 years was a condition for the inclusion in the RPA group, and a statement that a person has not been performing RPA for at least 2 years was a condition for inclusion in the control group. RPA is interpreted as performance of a particular sports discipline or activity at least twice a week (with the exception of off-season periods).

The study conformed to the standards set by the Declaration of Helsinki and was approved by the Bioethics Committee for Scientific Studies at The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland. All participants and their parents received verbal and written information about all procedures and gave their signed informed consent to participate.

#### 2.2. Procedures

The ultrasound scanning procedures were performed by 1 investigator. The entire procedure, the sequence of measurements, and the instructions were identical for all study participants.

A real-time ultrasound B-scanner (MINDRAY DP-6600 Digital Ultrasonic Diagnostic Imaging System; Medical Corp., Redmond, WA, USA) with a 60 mm wide 75L38EA linear array transducer (5.0/7.5/10 MHz) was used to obtain images of the abdominal muscles. The penetration depth was 5.39 cm at a sampling frequency of 7.5 MHz. The transducer was always placed on the anterolateral wall of the abdomen, between the iliac crest and the costal margin, perpendicular to the longitudinal axis of the body. It was finally adjusted to ensure that, at rest, the fascial borders of the 3 muscles (TrA, OI, OE) appeared parallel on the screen. Individuals with an unclear

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