TITLE: THE POSSIBILITY OF APPLYING ULTRASONOGRAPHY OF THE MAIN RESPIRATORY MUSCLES IN THE ANALYZING THE SPEED AND ENDURANCE IN ADOLESCENT FOOTBALL PLAYERS.

INTRODUCTION:

The effectiveness and result of a football match depend on players' motor skills, including endurance and speed. Physical activity is directly related to the functioning of the respiratory system, including the respiratory muscles. Training these muscles can enhance respiratory system function by reducing fatigue and dyspnoea, improving the quality of life. This work is a collection of publications relating to the: 1) current state of knowledge on ultrasound imaging of respiratory muscles, 2) establishing the methodology and determining the reliability of ultrasound examination of respiratory muscles in a group of adolescent football players, 3) initial estimation the degree of correlation between ultrasound parameters of the respiratory muscles with endurance and speed in adolescent football players.

PURPOSE:

The main aim of the study was to assess the possibility of using ultrasound imaging of the main respiratory muscles in the analysis of speed and endurance in adolescent football players. The aim was divided into three stages:

I. Conducting a systematic review of works analyzing the relationship of respiratory muscle assessment through ultrasound imaging with the translation of these results into respiratory system function.

II. Determination of the level of reliability of ultrasound examination of respiratory muscles in adolescent football players.

III. Analyzing the relationship between ultrasound parameters of diaphragm and intercostal muscles in relation to speed and endurance in adolescent football players.

The following hypotheses were formulated: a) motor skills such as endurance and speed are related to the thickness and elasticity of respiratory muscles (diaphragm, intercostal muscles) in adolescent football players; b) respiratory parameters directly linked to respiratory muscle strength should exhibit a stronger relationship with ultrasound parameters of respiratory muscles compared to respiratory parameters not directly tied to respiratory muscle strength.

METHODS:

I: A systematic review was conducted based on 5 databases. Articles analyzing the relationship between ultrasound parameters of respiratory muscles and respiratory parameters were included. Two investigators independently extracted and documented data on the study

population (age, gender, health status, methodology, ultrasound and respiratory parameters). The research underwent qualitative synthesis.

II: Diaphragm and intercostal muscle parameters (thickness and shear modulus) were measured by shear wave elastography in adolescent athletes. Measurements were taken during a tidal breath in two probe positions (transverse and parallel to the ribs). Repeated tests were performed after 7 days. Intraclass correlation coefficient (ICC) and the Bland-Altman test were used to calculate the reliability by a single investigator.

III: Ultrasound parameters of the diaphragm and intercostal muscles (shear modulus, thickness, excursion and excursion velocity), speed (30 m distance) and endurance parameters (multi-stage 20 m shuttle run test) were measured in 22 adolescent football players. The relationship between ultrasound examinations and running tests was analyzed using Spearman's rank correlation coefficient.

RESULTS:

I: Out of the 4,639 papers identified, 31 were qualified. The most frequently examined ultrasonography parameters of the respiratory muscles were diaphragm excursion and thickness. Among the respiratory parameters, the most frequently tested were forced vital capacity, forced expiratory volume 1 s and maximum inspiratory pressure. The relationships between respiratory and ultrasound parameters ranged from negligible to strong (depending on the study population and the methodology used). In most articles, diaphragm thickness correlated positively with forced vital capacity and forced expiratory volume 1 s (moderate-strong), with maximal nasal inspiratory pressure and maximal inspiratory pressure (moderate), and with maximal expiratory pressure and vital capacity (weak-moderate). Diaphragm excursion was significantly moderately correlated with most respiratory parameters. The data were not quantified due to high heterogeneity in terms of study design, study group, and various respiratory and ultrasound parameters.

II: The reliability for one-day measurements of the diaphragm and intercostal muscles (regardless of the probe orientation) was at least good. The reliability during the seven-day interval between measurements depended on the measured parameter, probe position, breathing phase and muscle. Excellent reliability of the diaphragm shear modulus at the end of tidal expiration in the transverse probe position ($ICC_{3.1}$ = 0.91–0.96; $ICC_{3.2}$ = 0.95) and poor to excellent reliability for intercostal muscle thickness at the end of tidal inspiration in the longitudinal probe position ($ICC_{3.1}$ = 0.26–0.95; $ICC_{3.2}$ = 0.15). Overall reliability of analyzed data was higher for measurements of the diaphragm (than intercostal muscles) regardless of the respiratory phase and probe position.

III: The shear modulus of the diaphragm at the end of a tidal inspiration was moderately negatively correlated with the speed score at 10m ($R = -0.49$; $p = 0.2$). The diaphragm and intercostal muscle shear modulus ratio were negatively correlated with the speed score at 10m and 30m (approximately $R = -0.48$; $p = 0.03$). Diaphragm excursion was positively correlated with speed scores at 5m ($R = 0.46$; $p = 0.04$) and 10m ($R = 0.52$; $p = 0.02$). Diaphragm excursion velocity was moderately positively correlated with speed scores at 5m ($R = 0.42$; $p = 0.06$) and 30m ($R = 0.42$; $p = 0.07$). Respiratory muscle thickness showed no significant correlations with speed scores. There was no significant correlation between endurance and ultrasound parameters of the respiratory muscles ($R \leq 0.36$; $p \geq 0.11$).

CONCLUSIONS:

Ultrasound parameters of respiratory muscles are partly related to respiratory parameters. Respiratory muscle ultrasonography may complement spirometry, but the exact role of ultrasound imaging in assessing the respiratory system requires further confirmation. Shear wave elastography seems to be a promising and reliable technique for examining diaphragm and intercostal muscles in adolescent athletes. Ultrasound parameters of the respiratory muscles (shear modulus of the diaphragm and intercostal muscles; diaphragm excursion and excursion velocity) are related to speed and unrelated to endurance in adolescent football players. The significance of respiratory muscle parameters for endurance and speed in young athletes' prognoses remains uncertain, warranting further research.

Key words: ultrasonography, shear wave elastography, diaphragm, intercostal muscles, respiratory system, adolescent athletes, motor skills