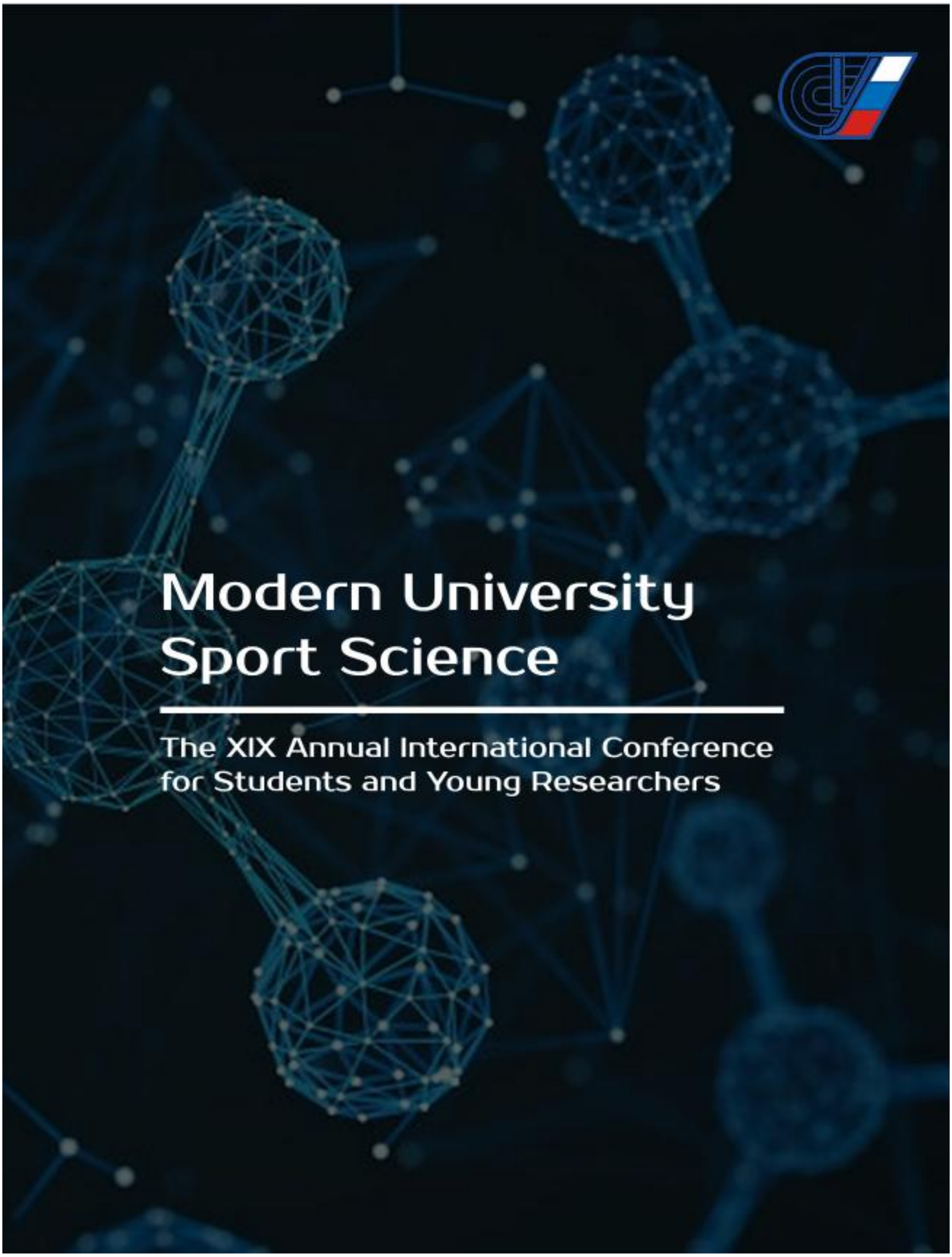

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A NEW APPROACH TO ADVANCED CORE STRENGTH AND POWER TESTING: FROM THE LAB TO THE FIELD

Zemková E.

Abstract. *Core stability and core strength are important performance factors for competitive athletes as well as the physically active population. Various dynamometers are usually used for their laboratory evaluation. In sports conditions, maximum isometric strength and endurance of trunk muscles are mainly tested, while muscle power is neglected. This article highlights the possibilities of using portable diagnostic systems to assess muscle strength and power during lifting tasks and trunk rotations simulating conditions in sports and activities of daily life.*

Keywords*: back muscles, lifting task, muscle power, muscular endurance, trunk rotations*

Introduction

Core stability and strength are an integral part of an athlete's performance in sports based on lifting tasks and torso rotations [18]. Better neuromuscular control of postural and core stability contributes to more efficient functional movements specific in a given sport [18]. However, fatigue of the trunk muscles caused by excessive loading on the spine due to high training volume and repetitive movements is a significant source of back problems in athletes [13]. Core strengthening and stabilization exercises, alone or in combination with athletic training, are used to improve athletic performance [1] and reduce back pain [15]. However, their effectiveness is controversial, as there is a lack of tests that take into account the specifics of individual sports or the age and performance level of individuals. They focus primarily on maximal isometric strength of the back muscles and their endurance [11, 12], while the force-velocity-power characteristics of exercises involving the use of core muscles are neglected [16]. This study highlights the possibilities of assessing muscle strength and power during lifting tasks and trunk rotations used in many sporting activities.

Assessment of muscle power during a lifting task

The deadlift to high pull exercise is used to assess the power produced during a lifting task [3]. The test consists of exercises in the form of deadlift to high pull performed with a gradual increase in load using a Smith machine or free weights until the weight at which the individual achieves maximal values of power. Although the test performed on the Smith machine is safer, the movement pattern from deadlift to high pull with free weights approximates the demands of many everyday and sporting activities. This test is reliable and also sensitive in detecting differences in performance within and between groups [3]. It can be applied to assess the performance of athletes and individuals whose work requires lifting weights, as well as people with a sedentary lifestyle [6].

Assessment of muscle power during trunk rotations

Isoinertial trunk dynamometers are typically used to assess speed and power during trunk rotations in laboratory conditions. In sporting field, test adapted from the woodchop exercise is used to assess power during trunk rotations [4]. Subjects perform repetitions of a standing cable woodchop exercise with increasing weights up to a weight at which maximal values of power are achieved. They may also perform a series of a certain number of repetitions with a predetermined weight to assess core muscle endurance. The power is calculated using the diagnostic system connected to the weight stacking machine. This test is reliable and also sufficiently sensitive to detect differences in trunk rotational power between physically active individuals, especially at higher weights [4].

Another alternative is a test consisting of trunk rotations with a barbell placed on the shoulders. Subjects perform two repetitions of trunk rotations to each side per a load with maximum effort in the acceleration phase. The load is gradually increased until the weight at which maximum power values are achieved. The diagnostic system consisting of an inertia measurement unit is mounted on the axis of the barbell.

Using this test, it was found that power is higher during standing than seated trunk rotations, with more pronounced differences at weights $\geq$10.5 kg [5]. This can be attributed to the greater range of motion of the trunk in a standing position compared to a seated position, which allows individuals to accelerate more forcefully at the beginning of the rotation. This results in greater trunk rotation velocity and, consequently, overall power output. While seated trunk rotations are suitable for sports like canoeing, standing trunk rotations are a more specific alternative for sports like baseball, golf, tennis, hockey, karate and so forth.

Another study showed significant differences in trunk rotational power and velocity among athletes with different core muscle strength demands during movements specific to their sport [14]. While the highest power is produced at higher velocities or at lower weights in ball sports players (golf, hockey, tennis) and combat sports athletes (tae kwon do, thai boxing, karate, boxing) who generate high force in a short period of time, the highest power at higher weights is produced in grappling sports athletes (judo, wrestling) who require a great explosive power of upper and lower body to lift and throw the opponent and water sports athletes (canoeing, kayaking) who exert a great force against the water [14]. These within- and between-group differences in power produced may be attributed to the specificity of training involving trunk rotation at different velocities under different loading conditions.

Additionally, significantly higher trunk rotational power on the dominant than the non-dominant side were found in golfers (~15%), tennis players (~12%) and ice-hockey players (~14%) at lower and/or higher weights whereas there were no significant side-to-side differences in a control group of physically active subjects (~7%) [10]. Accordingly, this parameter may be considered specific to their asymmetric loading during trunk rotations.

Regarding the gender, there are also differences in trunk rotational power in female and male gymnastic and dance athletes [17]. The power and velocity in the acceleration phase of trunk rotations is significantly higher in male than in female athletes when carrying loads from 10.5 kg to 20 kg. This can be attributed to their genetic predispositions and the specificity of their acrobatic and dance elements, including trunk rotations at different speeds under different loading conditions.

Regarding the age, velocity in the acceleration phase of trunk rotation and the respective angular displacement are significantly higher in young than in older adults (~21.8 and ~62.2 years old, respectively) [8]. Trunk rotation velocity is significantly correlated with trunk angular displacement, implying that slower trunk rotation velocity is most likely due to a limited range of trunk rotational motion, which is more apparent in older adults.

Furthermore, trunk rotational velocity and respective angular displacement are significantly lower in paralympic table tennis players compared to able-bodied athletes [9]. Values of thoracic kyphosis were similar in both groups. However, para table tennis players showed lower lumbar inversion and pelvic retroversion compared to able-bodied athletes. Trunk rotation velocity correlated with angular displacement in both groups, whereas with lumbar curvature and pelvic tilt angle only in para athletes. This suggests that the slower trunk rotation velocity in para table tennis players may be due to their limited range of trunk rotational motion, to which their reduced posterior concavity may have also contributed.

Moreover, the intervention study showed that mean power during the acceleration phase of trunk rotations increased significantly after both 6 weeks of preparation period and 6 weeks of competition period (at weights ranging from 10 to 26 kg and 6 to 26 kg, respectively) in tennis players [2]. However, its values increased significantly only after a 6-week preparation period in ice hockey players (at weights ≥12 kg) and canoeists (at weights ≥10 kg) [2]. These findings indicate that changes in trunk rotational power reflect the specificity of their training programs. This information may provide a basis for designing exercises aimed at improving the power produced during trunk rotations under different load conditions [7].

Conclusion

This work presents a new approach to advanced testing of core strength and power in sports field conditions using portable diagnostic systems. This includes primarily the assessment of muscle power during lifting tasks with different weights in physically active and sedentary subjects. There are also tests assessing power and velocity during trunk rotations with different weights in standing or sitting position. Sport-specific differences in force-velocity-power profiling during trunk rotations under different loads were demonstrated, as well as between-side differences in trunk rotational power in athletes trained in asymmetric sports, and gender differences in trunk rotational power in gymnastic and dance athletes. The relationship between trunk rotation velocity and range of angular motion in young and older adults was also presented, as well as the association of trunk rotation velocity with mobility and spinal curvature in para table tennis players. Finally, the use of these tests to assess the effect of sport-specific training in the preparatory and competitive periods on trunk rotational power was also provided. These information are useful in assessing core strength and power in individuals of different ages and performance levels, the acute effect of fatigue on the parameters of these abilities, and their changes during different training periods.

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