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ASSESSING CORE MUSCLE STRENGTH AND FUNCTION IS KEY FOR PERFORMANCE IMPOVEMENT

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ABSTRACT

This paper presents our experience with the assessment of the strength and function of core muscles to increase the performance of athletes and possibly predict back problems in individuals with excessive spinal load, or on the contrary, with weakened back muscles due to a sedentary lifestyle. Tests assessing velocity and power produced during lifting tasks and trunk rotations can be used for this purpose. Our reseach showed that these tests are reliable and sensitive in differentiating individuals of various ages and performance levels, as well as in revealing the effectiveness of exercise programs focused on improvement of core muscle strength and function.

ASSESSING CORE MUSCLE POWER DURING LIFTING TASKS AND TRUNK ROTATIONS

In order to assess power during a lifting task, a deadlift to high pull exercise with stepwise increasing loads using either the Smith machine or free weights can be used (Zemková et al., 2016). Peak and mean power obtained from this test has been found to be reliable and sensitive in differentiating between physically active and sedentary young adults (Zemková et al., 2016).

In order to assess velocity and power produced during trunk rotations, torso isoinertial dynamometers can be used in laboratory conditions. However, the test adapted from the woodchop exercise, where diagnostic system is directly connected to the weight stack machine, is more suitable for fitness-oriented testing (Zemková et al., 2017a). The subjects perform single repetitions of the cable woodchop exercise in standing or in sitting position with increasing weights up to the weight at which maximal values of power are achieved. They can also perform a set of a pre-defined number of repetitions at a previously established weight to assess strength endurance of the trunk muscles. This test is reliable and sensitive in differentiating between physically active individuals with different performance levels, particularly when it is performed with higher weights (Zemková et al., 2017a). Another alternative is trunk rotations performed with free weights. Subjects perform trunk rotations with a bar over the shoulders with weights increasing from 1 kg by ~5 kg up to a max. of 50 kg. The equipment consisting of an inertia measurement unit (a combination of a three-axis accelerometer and three-axis gyroscope) is inserted in the bar axis. In practice, the power expressed relative to body weight should be used instead of its absolute values, namely for athletes performing standing trunk rotations in their sports. In addition, mean power rather than peak power should be used for data analysis, as it represents a more reliable parameter. In both cases, trunk rotations can be performed while sitting or standing. Standing body rotations allow for greater lower body engagement and contribution of thoracic and hip mobility than seated rotations. The greater range of rotational movement of the trunk in standing than in sitting allows the subject to accelerate the movement more forcefully at the beginning of the rotation. This results in higher velocity and power production in the acceleration phase of trunk rotation, as well as a respective angular displacement in standing than in sitting trunk rotation at weights ≥ 10.5 kg (Zemková et al., 2017b). Furthermore, the strong relationship between the power produced during the standing and seated trunk rotations with a weight of 5.5 kg suggests that these exercises are similar in terms of power production. However, low correlations between power produced during standing and seated trunk rotations at ≥10.5 kg suggest that these tests measure different qualities. While seated trunk rotations are suitable for sports such as canoeing, standing trunk rotations would be a more specific alternative for many other sports such as baseball, golf, tennis, hockey or karate and boxing.

ASSESSING CORE MUSCLE POWER IN ATHLETES OF VARIOUS SPORTS AND PERFORMANCE LEVELS

Our preliminary studies have shown that trunk rotational velocity and/or power are the highest in ice-hockey players and canoeists, followed by rock & roll dancers, judoists, wrestlers, tennis players, golfers, karateists, and finally ballroom dancers, with small differences depending on the additional load used (1 kg or 20 kg). A comparison of individual values also revealed higher trunk rotational velocity and/or power in a canoeist than a rower, a weightlifter than a bodybuilder, and an ice-hockey player than a karateist. These differences may be attributed to their training specificity involving trunk rotations at various velocities under various load conditions.

Further study showed that 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 (Zemková et al., 2020). On the other hand, the highest power is produced at lower weights or at higher velocities 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 (Zemková et al., 2020). The highest values of power are achieved in combat sports athletes (max. at 10.5 kg), followed by water sports athletes (max. at 20.0 kg), grappling sports athletes (max. at 15.5 kg), and ball sports athletes (max. at 10.5 kg). Furthermore, angular velocity is the highest at higher weights in water sports athletes and at lower weights in combat sports athletes. Water sports athletes produce the highest force at lower velocities, whereas combat sports athletes produce the highest force at higher velocities. These between-group differences in force–velocity–power production during trunk rotations may be ascribed to the specificity of their training methods used (Zemková et al., 2020).

Trunk rotational velocity and power is also assessed in athletes of gymnastic (aerobic and acrobatic gymnastics) and dance sports (ballroom and rock & roll dancing). Their values are significantly higher in males than in females at weights ≥10.5 kg (Zemková et al., 2022). Alternatively, power and force are greater at higher velocities in females than in males. The highest power is usually produced at 15.5 kg in males and at 10.5 kg in females. These gender differences in trunk rotational power and velocity can be attributed mainly to the specificity of their acrobatic and dance elements including repetitive body rotations.

For athletes trained in asymmetric sports, it is also appropriate to assess side-to-side differences in trunk rotational velocity and power. Its values are higher on the dominant than non-dominant side in golfers (11.9%) and tennis players (9.4%), whereas there are no significant between-side differences in a control group of physically active subjects (6.2%). Similarly, power produced in the acceleration phase of trunk rotations is significantly higher on the dominant than the non-dominant side in golfers (~15%), ice-hockey players (~14%) and tennis players (~12%) compared to no significant between-side differences in a control group of physically active subjects (Zemková et al., 2019). As these asymmetries may represent an increased risk of low back pain and related injuries, a parameter expressed as a dominant/non-dominant power ratio could be considered specific for identifying the likelihood of back problems in athletes trained in sports such as golf, tennis, hockey and so on

Another group, in which trunk rotational velocity assessment can be applied, is wheelchair athletes. We found that paralympic table tennis players produce lower velocity in the acceleration phase of trunk rotations compared to able-bodied athletes (Zemková et al., 2018b). Additionally, lumbar inversion and pelvic retroversion were lower in para table tennis players compared to able-bodied athletes. However, values of thoracic kyphosis were similar in both groups. Furthermore, trunk rotational velocity correlated with angular displacement in both groups, while with lumbar curvature and pelvic tilt angle only in a group of para table tennis players. It is therefore very likely that slower velocity of trunk rotations in para table tennis players may be due to their limited range of trunk rotational motion. A reduced posterior concavity could also contribute to these lower values. However, other biomechanical factors may also play a role in the relationship between these variables.

Due to the fact that even middle-aged and older recreational athletes are engaged in sports such as tennis or golf, it is necessary to include the assessment of velocity or power produced during trunk rotations in their test battery. We found that velocity in the acceleration phase of trunk rotation and the respective angular displacement are significantly lower in older than young adults (Zemková et al., 2018a). A slower velocity of trunk rotations in older adults is most likely due to their limited range of trunk rotational motion. This was corroborated by the significant correlation between these variables, with older than young adults accounting for a higher proportion of variance. Increased trunk stiffness in the older adults could contribute to a significant interaction between age and trunk angular displacement in determining trunk rotation velocity.

ASSESSING CORE MUSCLE POWER AFTER VARIOUS TRAINING PROGRAMS

One study evaluated changes in trunk rotational power at different weights and velocities after 6-week preparatory and 6-week competitive periods in ice-hockey players, tennis players, and canoeists (Poór and Zemková, 2018). In tennis players, mean power in the acceleration phase of trunk rotations increased significantly at weights from 10 to 26 kg after the preparatory period and at 6 to 26 kg after the competitive period. In ice-hockey players, the trunk rotational power significantly increased at weights ≥12 kg after the preparatory but not after the competitive period. In canoeists, the values of power produced during trunk rotations significantly increased at weights ≥10 kg only after the preparatory period. These changes in trunk rotational power reflect the specificity of their training in preparatory and competitive periods and provide a basis for designing exercise programs for improvement of core muscle strength and function.

Another study investigated the effect of 12-week core strengthening and weight training on muscle strength, endurance and flexibility in school-aged athletes (Kumar and Zemková, 2022). Ninety male athletes aged 12 years were randomly divided into group one, which underwent core strengthening training, group two, which underwent weight training, and a third control group. The training was for 12 weeks, with three sessions per week (one hour per session). Both experimental groups improved more in abdominal strength, endurance, and flexibility compared to the control group. Furthermore, abdominal strength and endurance improved slightly more after the weight than core strength training, whereas flexibility increased slightly more after the core strength than weight training. This indicates that both core strengthening training and weight training are effective in improving physical fitness in school-aged athletes; however, the improvement is to differing extents regarding their endurance, flexibility, and abdominal strength.

Third study evaluated the effect of 3-month resistance training and 3-month aerobic training on power produced during a modified lifting task, in the form of deadlift high pull with increasing weights up to maximal power, in overweight and obese subjects (Zemková et al., 2017c). The power significantly increased during a lifting task with weights from 30 to 50 kg (~40%⁻ 60% of 1 RM) after the resistance training but not after the aerobic training in the overweight and obese.

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