Change in the muscle activity of the lower limbs of hockey players in the phases of acceleration and uniform skating

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Abstract

Objective of the study is to study the changes in the muscle activity of the lower limbs of hockey players in the phases of acceleration and uniform skating during forward movement.

Methods and structure of the study. The hockey players performed skating at maximum speed over a distance of 30 m from a stationary position at the start. Muscle activity was measured on the basis of the registration of EMG signals in the acceleration phase and the uniform skating phase. The EMG waves of each muscle were normalized relative to the peak step intensity in the steady-state mode.

Results and conclusions. The main factor influencing the push-off forces in the acceleration phase is the activity of the medial gastrocnemius muscle. During uniform skating, the increased activity of the vastus lateralis and vastus medialis muscles provides a greater speed of extension and a greater skating speed.

Keywords: *hockey players, muscle activity, acceleration phase, uniform skating phase.*

Introduction. The movements performed on the speed-skating track are limited to linear and cyclic movements. At the same time, the game of hockey includes accelerations, changes of direction, sudden stops, and cross-over movements, which are quite difficult to record in laboratory conditions [4].

A study of the three-dimensional kinematics of the lower limbs of hockey players of various levels of preparedness on a skating simulator showed significant advantages of highly qualified players in stride length, segmental movements, and an increased range of motion in the joints [3].

The muscle activity of the lower limbs of hockey players during running at various speeds on the speed-skating track was also studied [1]. It was established that an increase in speed leads to enhanced activation of the hip flexors, knee extensors, and plantar flexors of the ankle joint. Kinematic data of skating were also recorded using portable high-speed cameras mounted on the boards of the hockey rink [2].

To date, there are no studies considering the combination of kinematic characteristics and muscle activity during forward movement.

Objective of the study is to study the changes in the muscle activity of the lower limbs of hockey players in the phases of acceleration and uniform skating during forward movement.

Methods and structure of the study. The scientific work involved 10 players of the main lineup of a student team aged 20.5±0.7 years, weighing 78.4±5.3 kg, with a height of 178.0±5.5 cm, and 8 beginner hockey players aged 19.9±0.3 years, weighing 77.3±9.8 kg, with a height of 177.8±4.6 cm.

The hockey players performed skating at maximum speed over a distance of 30 m from a stationary position at the start. The time of performing the exercises was measured using light gates located every 10 m from the start line. This made it possible to record the time of covering the first 10 m (the acceleration phase), the last 10 m (the uniform skating phase), and the entire segment of the distance.

To quantitatively assess the vibrations upon contact of the blade with the ice at the moment of push-off, a 3D accelerometer with a measurement range of ± 35 g was installed on the right skate in the center of the blade. The voltage signals from the accelerometers were recorded and converted into units of gravity (g) by means of calibration in a range of motion of 180°.

Muscle activity was measured on the right leg using bipolar surface electrodes fixed to the skin with an elastic band. The electromyographic (EMG) signals were amplified and sampled at a frequency of 2400 Hz.

In accordance with the phase of contact of the skate with the ice (% of contact) at which the muscle activity was maximal, the biomechanical data at the 2nd and 8th steps of the hockey players were extracted and time-normalized. Contact with the ice was limited by the occurrence and cessation of high vibration amplitudes in the signal of the skate blade accelerometer. The selected steps represented the acceleration phase and the uniform skating phase.

To convert the raw EMG signals into the frequency-time space, the technique of wavelet analysis with 13 nonlinearly scaled wavelets (central frequencies varied from 6.9 Hz to 542 Hz) was used [10].

For the analysis of the signal power, the total EMG intensity was summed over wavelets 2–11. Maximal voluntary contractions were not performed, therefore the EMG waves of each muscle were normalized relative to the peak step intensity in the steady-state mode measured for that muscle. Thus, potential changes in the mechanisms of muscle activation in various phases of the step were studied depending on the type of step; intergroup comparisons were not carried out.

As a statistical measure of similarity for assessing the repeatability of the wave oscillations, the coefficient of multiple correlation was used.

Results of the study and discussion. The participants of the main lineup of the team, in comparison with the beginner hockey players, showed a better time in the acceleration phase, the uniform skating phase, and the 30-meter distance race as a whole ($p<0.05$). A significant relationship was observed between the level of preparedness of the players and the difference in the time of covering the segments; in the beginner players, the difference between the time of the acceleration and uniform skating phases turned out to be substantially greater than in the hockey players of the main lineup (Table 1).

The positive percentage ratio according to the EMG data during contact with the ice indicates greater muscle activity during the uniform skating phase (Table 2).

When comparing the mode of muscle work in various phases of skating, it was established that, in comparison with uniform skating, the activity of the medial gastrocnemius muscle is significantly higher during the acceleration phase ($p<0.05$). On the other hand, the vastus lateralis and vastus medialis muscles exhibited greater muscle activity during uniform skating ($p<0.05$). For the gluteus medius muscle and the tibialis anterior muscle, no significant differences were observed between the uniform skating phase and acceleration.

The increased activity of the knee-joint extensor muscles is an important mechanism providing greater knee extension during the propulsive phase of the skating step. In this regard, it can be assumed that a high skating speed can be achieved through

Table 1. Time of covering the segments of the 30 m distance at maximum effort in skating

Players	Acceleration		Uniform skating		Distance 30 m	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Main lineup	1.89	0.06	1.18	0.08	4.49	0.18
Beginners	2.31	0.08	1.28	0.09	5.36	0.26

Table 2. Changes in the total muscle activity according to the EMG data, $\bar{x}$±SD (%)

Phase	Muscle				
	Medial gastrocnemius	Gluteus medius	Tibialis anterior	Vastus lateralis	Vastus medialis
Acceleration	6.4±0.15	-	5.9±0.11	-	-
Uniform	-	5.1±0.08	-	12.9±0.16	9.4±0.12

accentuated training of the knee-joint extensor muscles.

The smaller angles of knee extension during accelerated skating can also be explained by the high activity of the medial gastrocnemius muscle during these steps. Knee flexion is a secondary function of the gastrocnemius muscle, therefore the significantly greater activity of this muscle in the acceleration phase could have contributed to the lower angle of knee extension.

In the ankle joint, the gastrocnemius muscle acts as a powerful plantar flexor, which is necessary during acceleration in order to provide push-off from a static position. As a result, the maximum and average push-off force turned out to be significantly greater during acceleration. Thus, in the acceleration phase during push-off, a predominance of the activity of the plantar flexors is observed, which limits the range of motion in the knee joint and increases the force of plantar flexion. However, during uniform skating, the increased activity of the knee-joint extensor muscles provides a greater speed of extension and, consequently, a greater skating speed.

Conclusions. The conducted study revealed the acceleration phase as the basis of the skating technique of hockey players, which to the greatest extent distinguishes hockey players of various levels of preparedness. The activity of the medial gastrocnemius muscle is the main factor influencing the push-off forces during the acceleration phase. During uniform skating, the increased activity of the vastus lateralis and vastus medialis muscles provides a greater speed of extension and, consequently, a greater skating speed.

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