Current problems of technical training of young ski racers in Russia

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Abstract

Objective of the study was to analyze the kinematics of skating ski moves of young cross-country skiers and determine ways to optimize the technical training of athletes.

Methods and structure of the study. At the Russian Youth Cross-Country Championships, video footage of skating movements on the slopes and on the flat was taken. The biomechanical characteristics of the skating movements of boys aged 14-16 years were calculated in the Dartfish Pro program and compared with the indicators of the strongest ski racers in the world.

Results and conclusions. The data obtained made it possible to identify the main technical mistakes of young athletes and suggest ways to improve long-term technical training. The reason for the majority of technical errors among young men is an insufficient level of coordination abilities, in particular, balance, the ability to accurately and timely dose efforts, timely change the mode of muscle operation depending on external conditions, as well as low core stability. It is proposed to change approaches to training children, starting from the initial training stage, to place emphasis on creating a broad foundation of motor skills that allow not only to master a biomechanically advantageous structure of movements, but also to develop the ability to timely vary the magnitude, direction and duration of efforts.

Keywords: *cross-country skiing, young ski racers, highly qualified ski racers, technical training, skating, video analysis, biomechanical characteristics.*

Introduction. One of the important components of the training process of highly qualified cross-country skiers is technical training [1]. Effective, stable and economical skiing technique allows one to show high results at the international level and realize the athlete's motor potential in the conditions of major competitions [3]. At the same time, young athletes who join the Russian cross-country skiing teams often have two main problems in technical training: improperly formed motor skills and the inability to change the structure of movements depending on changing external and internal conditions. And if in most cases coaches and specialists manage to solve the first problem, although this requires significant effort and time, then it is almost impossible to predict and create the most beneficial regime of muscle effort in the upcoming races, since competitive conditions change unpredictably.

To improve the technical training system for young cross-country skiers, it is necessary to formulate requirements for skiing technique in accordance with the modern realities of cross-country skiing [2].

Objective of the study was to identify the features of the kinematics of skating ski moves of young cross-country skiers and determine ways to optimize the technical training of athletes.

Methods and structure of the study. In the winter season 2021-2022. Video filming of the skating

skiing technique of young ski racers aged 14-16 years was made at the Russian Championship, as well as video filming of the movements of the strongest skiers in the world at the stages of the World Cup, which took place during the same period. The conditions for video filming were standard: a Sony HDR-CX 730 EV video camera was installed motionless perpendicular to the ski track so that at least 3 cycles of movements were captured in the frame. The second video camera was used to film "with wiring" for visual analysis of the equipment in the frontal plane. The resulting video recordings were processed in the Dartfish Pro program, and the kinematic indicators of the best young and adult athletes at each distance were determined. On the flat sections of the competitive distances, the characteristics of the simultaneous one-step skating (SOSS) moves were determined, and on the hills - the simultaneous two-step skating (STSS) moves. Statistical data processing was performed in the RStudio program. The hypothesis about the significance of intergroup differences was tested using the nonparametric Mann–Whitney test.

Results of the study and discussion. Three groups of indicators in skating skiing in boys and men were analyzed: tempo-rhythm characteristics (tempo of movements, cycle time, duration of the push-off and rolling phases), angular values of the key moments of the stroke cycle and angular velocities of movement in the joints.

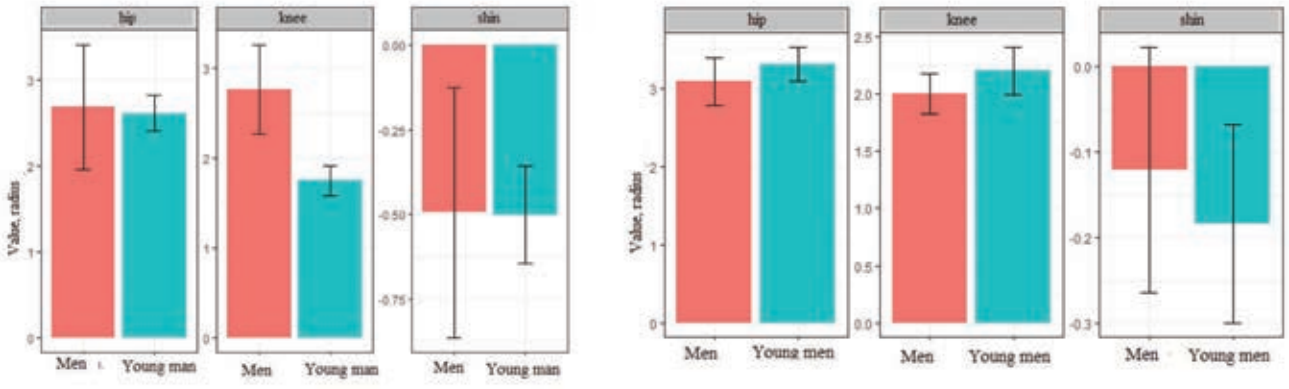
Analysis of tempo-rhythm characteristics (Table 1) shows that when moving with a simultaneous one-step move on the plain, the strongest riders performed a faster take-off and a longer sit-down. In all cases, the moment of sitting down was considered to be the position of the skiers in which the knees were aligned (located in the same transverse plane). Adult highly skilled skiers simultaneously perform a lunge of the fly leg and active extension of the supporting leg, and

Table 1. Comparison of tempo-rhythm characteristics of skating moves of young and adult cross-country skiers

Move	Indicators	Boys, n=50	Men, n=18	Statistical significance of differences, p
SOSS	Movement rate, cycle/min	62,51±4,03	63,68±3,44	>0,05
	Repulsion time, s	0,30±0,05	0,23±0,02	**<0,01**
	Time of squatting, s	0,15±0,04	0,19±0,02	**<0,01**
STSS	Movement rate, cycle/min	58,28±4,79	54,8±4,24	**<0,05**
	Repulsion time, s	0,28±0,04	0,30±0,05	>0,05
	Time of squatting, s	0,27±0,04	0,28±0,03	>0,05

Table 2. SOSS angular characteristics of young and adult cross-country skiers, (degrees, $\bar{X}$ ±σ)

Moment of the ski cycle	Angular characteristics	Boys, n=50	Men, n=18	Statistical significance of differences, p
Supporting leg at the moment of placing the poles	Shin tilt	71,89±5,11	75,87±6,83	**<0,05**
	Knee	138,81±8,3	138,31±8,39	>0,05
	Hip	118,55±6,02	121,38±8,39	>0,05
	Torso tilt	50,96±4,13	50,75±3,74	>0,05
Supporting leg at the moment of squatting	Shin tilt	68,90±4,7	69,63±6,03	>0,05
	Knee	121,68±6,22	113,78±8,41	**<0,001**
	Hip	94,62±7,55	94,52±11,58	>0,05
	Torso tilt	41,60±4,78	39,22±3,01	**<0,05**
The pushing leg at the end of the push-off	Shin tilt	60,01±8,4	63,19±7,61	**<0,05**
	Knee	150,89±7,38	149,78±8,51	>0,05
	Hip	138,75±11,47	129,37±21,62	>0,05
	Torso tilt	48,70±4,71	48,29±5,73	>0,05



Angular velocities of repulsion in SOSS (left) and STSS (right)

Table 3. STSS angular characteristics of young and adult cross-country skiers, (degrees, $\bar{X}$ ±σ)

Moment of the ski cycle	Angular characteristics	Boys, n=50	Men, n=18	Statistical significance of differences, p
Supporting leg at the moment of placing the poles	Shin tilt	69,01±5,55	66,24±5,47	>0,05
	Knee	120,08±9,80	117,88±5,40	>0,05
	Hip	91,78±8,51	94,07±5,31	>0,05
	Torso tilt	52,4±5,05	53,82±3,66	>0,05
Supporting leg at the moment of squatting	Shin tilt	59,06±3,96	56,96±2,23	**<0,05**
	Knee	117,13±6,93	116,27±4,87	>0,05
	Hip	84,61±6,94	94,26±3,57	**<0,001**
	Torso tilt	39,66±5,08	45,68±3,44	>0,05
The pushing leg at the end of the push-off	Shin tilt	56,13±6,64	54,98±5,93	>0,05
	Knee	152,62±11,43	150,89±4,67	>0,05
	Hip	138,11±12,47	147,37±7,45	**<0,01**
	Torso tilt	57,06±5,36	59,84±3,51	**<0,05**

young men, starting a step, continue to bend the supporting leg for some time, which leads to an increase in the duration of the take-off period and a shortening of the step length.

When moving with a simultaneous two-step skating move on an incline, the majority of young skiers did not make such technical errors, and the duration of the sit-up and take-off did not have statistically significant differences with the indicators of men (p>0.05). Analyzing the angular indicators, it should be noted that the absolute values of the joint angles largely depend on the speed of movement, the applied effort, relief, morphological indicators and physical capabilities of the athletes. Thus, during tactical accelerations, the values of the ankle, knee and hip joints decrease, and with uniform economical movement, they increase. This does not allow researchers to determine universal model indicators and creates difficulties in kinematic analysis, however, measuring and comparing the values of joint angles makes it possible to determine their optimal ratio, and most importantly, provides a tool for the coach to help explain to the athlete what exactly needs to be changed in the technique.

Reducing the angle of inclination of the shin at the moment of placing the poles allows young men to bring the projection of the center of gravity closer to the foot of the supporting leg and may be a sign of economization of technique (Table 2). A smaller angle in the knee joint in adult athletes during a squat indicates preparation for an active push-off. Young athletes compensate for insufficient flexion of the supporting leg by tilting the torso. A smaller angle of inclination of the shin at the moment of completion of the push may indicate a prolonged push-off.

When moving on a climb with a simultaneous two-step stroke, the strongest skiers, at the moment of squatting, more actively tilt their shins forward, which allows them to shift their pelvis forward (Table 3). The technique of young men is characterized by a large amplitude of body swaying, which is manifested in an excessive decrease in the angle of the hip joint and the angle of inclination of the body. Statistically significant differences in these indicators indicate insufficient stabilization of the trunk muscles, especially against the background of fatigue.

In competitive conditions, it is impossible to measure dynamic characteristics, however, the angular velocities of movement in the joints make it possible to indirectly judge the applied force. Measurement of the average angular velocities of repulsion (see figure) showed that statistically significant differences between the indicators of the two groups of athletes were determined only in the speed of knee extension in a simultaneous one-step stroke ($p<0.001$).

Conclusions. The study of the kinematics of ski moves of young cross-country skiers revealed the following features:

- when moving with a simultaneous one-step skating stroke on the plain, in comparison with adult qualified skiers, young men make a long push-off - 0.30±0.05 s and a quick sit-down - 0.15±0.4 s. During the sit-up, young racers demonstrate larger angles in the knee joint - 121.68±6.24° compared to the strongest athletes (113.78±8.41°);

- when moving with a simultaneous two-step skating stroke on the rise, at the moment of sitting down, the young men do not actively tilt the lower leg - 59.06 ± 3.96°, which is accompanied by excessive flexion in the hip joint - 84.61 ± 6.94° and tilt of the body - 39.66 ± 5 .08°.

The data obtained allow us to assert that in the technical training of young ski racers it is possible to focus on the criteria for the effectiveness of skiing, developed for adult athletes. The reason for the majority of technical errors among young men is an insufficient level of coordination abilities, in particular, balance, the ability to accurately and timely dose efforts, timely change the mode of muscle operation depending on external conditions, as well as low core stability.

It is necessary to change approaches to training children, starting from the initial training stage, to place emphasis on creating a broad foundation of motor skills that allow not only to master a biomechanically advantageous structure of movements, but also to develop the ability to timely vary the magnitude, direction and duration of efforts.

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