Video analysis as a biomechanical assessment tool for Nordic walking techniques

UDC 796.012

PhD, Associate Professor **M.A. Samsonov**[1]
PhD, Associate Professor **V.V. Fursov**[1]
PhD, Professor **N.V. Kolesnikov**[2]
PhD, Associate Professor **S.I. Striga**[2]
[1]Lesgaft National State University of Physical Education, Sports and Health, Saint-Petersburg
[2]Russian Academy of National Economy and Public Administration, St. Petersburg

Corresponding author: kolesnikov.n@mail.ru

Received by the editorial office on 28.04.2025

Abstract

Objective of the study is to scientifically substantiate the methodology of video filming and analysis of Nordic walking technique.

Methods and structure of the study. In order to comprehensively study the mechanics of Nordic walking, a study was organized with the participation of the honored athlete, champion of Russia in competitive sports, Irina Markova. The venue for the experiment was the track and field arena of the Lesgaft National State University of Physical Education, Sports and Health. Before the video recording began, contrasting marks with a diameter of 1 centimeter were attached to the key joints of the subject. This was done to ensure their visibility at different angles and in the necessary projections.

Research results and conclusions. The method of multi-plane high-speed video recording of Nordic walking turned out to be quite convenient and relatively easy to prepare and set up equipment. The video recording features included high demands on additional lighting with high light output and the presence of two operators whose actions must be clearly coordinated.

The video analysis method using the Kinovea program turned out to be quite labor-intensive, given the number of characteristics being studied, but quite accurate, especially for determining kinematic characteristics (when determining time characteristics, the error was 0.002 s, with spatial characteristics – from 0.01 to 0.02 m).

Using this method, you can easily obtain excellent illustrative material in different planes of an athlete's movement, which can then be used both to study the technique of a specific athlete and for demonstration during training of other athletes.

Keywords: *analysis of Nordic walking technique, biomechanics of Nordic walking, high-speed video filming, multi-camera video filming, biomechanical analysis, analysis using the Kinovea program.*

Introduction. "Scandinavian" or "Nordic" walking refers to walking with poles specially designed for this purpose. Three main areas can be distinguished: health-improving, competitive, and "Nordic skills" (where only the technique of execution is assessed). Most of both domestic and foreign studies are devoted mainly to the health-improving area [2, 6, 8, 10].

There are much fewer studies in the field of competitive and "Nordic skills" areas. From the point of view of biomechanics, the technique of Nordic walking has been very poorly studied, especially the relationship between the kinematic parameters of the technique and their influence on the result shown by the athlete. Domestic studies devoted to the biomechanics of Nordic walking mainly consider the inclusion of certain muscles and muscle groups – this confirms its health-improving effect on the entire body as a whole [2].

From the results of foreign studies it follows that the use of poles allows reducing the effort to control the vibrations of the body and can contribute to higher productivity of the body relative to its energy expenditure. Electromyography has proven greater involvement and activation of muscles, especially the upper body, compared to regular walking [9].

Despite the fact that many researchers have proven the differences between Nordic walking and regular walking, a number of authors have shown the absence of significant differences in kinematic, kinetic and dynamic parameters between them. It has been

revealed that biomechanical gait parameters depend most strongly on speed, rather than on walking style [8].

Based on a review of 42 publications devoted to the biomechanical aspects of Nordic walking, it was found that when practicing Nordic walking, compared to regular walking, a number of kinematic characteristics positively increase, such as: distance traveled (+14.8%, $p<0.05$), walking speed (+25.5%, $p<0.05$) and step length (+10.4%, $p<0.05$). However, the walking pace decreases (-6.2%, $p<0.05$) [10].

Thus, the overwhelming majority of sources mainly touch upon the health direction and study the competitive and "Nordic skills" direction much less. In this regard, a study was conducted in which the competitive version of the Nordic walking technique was studied from the point of view of biomechanics.

Objective of the study is to scientifically substantiate the methodology of video filming and analysis of Nordic walking technique.

Methods and structure of the study. For a detailed analysis of the Nordic walking technique, a study was conducted, in which the Russian champion in competitive disciplines, Irina Markova, participated. The study was conducted in the track and field arena of the NSU named after P.F. Lesgaft. Before filming, contrasting markers measuring 0.01 m were glued to the centers of all the subject's joints so that they were visible in all the necessary planes (Fig. 1).

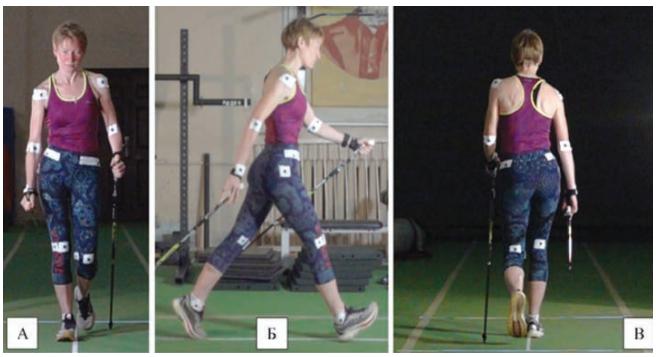

Fig. 1. Subject marking: A – frontal plane, front view, B – sagittal plane, B – frontal plane, back view

The place where the experiment was conducted was prepared in advance; the 50 mm thick track surface allowed for the full use of special poles. Markings were applied to the track at the location of the control section for the precise placement of cameras and subsequent determination of the scale. The distance between the marks was 2 m. Additional equipment for filming included two tripods and additional lighting with a total luminous flux of 67,000 lumens. To conduct the study, two cameras, SonyRX 100 m5 and SonyRX 100 m6, were selected, capable of high-speed video recording in the required quality for subsequent video analysis [3, 4].

Based on the results of test video shooting, it was established that when filming in the frontal plane, passing behind the athlete, the hands and poles do not cover the necessary markers, so the video filming of the main attempts was carried out from behind with the second camera. Video filming was carried out simultaneously from two cameras with the "quality priority" settings, mounted on a tripod with a frequency of 500 fps in the frontal plane (from behind) at a distance of 5.6 m and in the sagittal plane (from the side, on the right) at a distance of 8 m from the control lines that the subject passed [4, 5].

To synchronize the video materials from the two cameras, a bright flash of a smartphone flashlight was used, which was visible in the lenses of both cameras. After the video filming, further video analysis of the obtained materials was carried out.

Research results and conclusions. Calculation of all kinematic characteristics and video analysis of the obtained results were performed using the Kinovea 0.9.5 program. based on the experience of our previous studies [5].

Video analysis included the determination of a large number of kinematic characteristics of the motor action in order to understand their relationship with each other. The following were determined: minimum, maximum and average speed of the athlete (m/s), length of a double step (m), angle of forward torso tilt in the sagittal plane (deg), maximum angle of pelvis tilt in the frontal plane from behind (deg), duration of support of the right and left legs (ms), duration of the double phase of support (ms), duration of support of the left and right poles (ms), as well as their total duration of support, duration of transfer (being not on the support) of the left and right poles (ms), as well as their total transfer time, angles of placing the right and left poles on the support (deg), angles of "removal" from the support of the right and left poles (deg).

All obtained characteristics were exported to Excel and subjected to additional calculations, which were subsequently used to obtain statistical data and the final results of the study. The speed of body movement was calculated by the center of the athlete's ear using the "Movement" tool of the Kinovea program. The angle of the torso in the sagittal plane was determined

between the vertical and the line drawn from the center of the ear to the marker glued to the central part of the torso in the area of the apex of the iliac bone of the pelvis (Fig. 2).

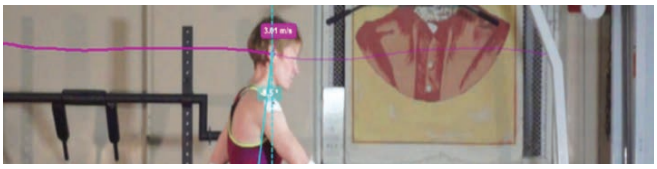

Fig. 2. Methodology for determining the speed of movement of an athlete and the angle of inclination of the body in the sagittal plane

In the frontal plane, the angle of tilt (abduction) of the pelvis was determined by video recording in the frontal plane, passing behind the athlete, between the horizontal and the line drawn between the markers glued to the tops of the iliac bone of the pelvis. Its value corresponded to the moment of the greatest tilt of the pelvis, Fig. 3.

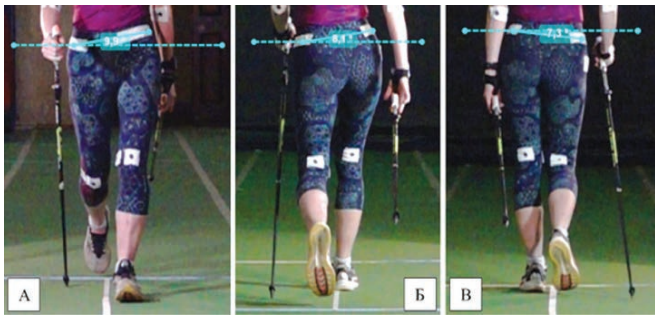

Fig. 3. Method for determining the angle of the pelvis in the frontal plane: A – frontal plane, front view, first step, B – frontal plane, rear view, first step, B – frontal plane, rear view, second step

The duration of support was determined based on video recording of the athlete in the sagittal plane frame by frame for each leg with an accuracy of 0.002 s. Then the total time of support was determined by adding these indicators.

Conclusions. The method of multi-plane high-speed video recording of Nordic walking turned out to be quite convenient and relatively easy to prepare and set up equipment. The features of video recording include high demands on additional lighting with high light output and the presence of two operators whose actions must be clearly coordinated. The video analysis method using the Kinovea program turned out to be quite labor-intensive, given the number of characteristics being studied, but quite accurate, especially for determining kinematic characteristics (when determining time characteristics, the error was 0.002 s, with spatial characteristics – from 0.01 to 0.02 m). Using this method, you can easily obtain excellent illustrative material in different planes of an athlete's movement, which can then be used both to study the technique of a specific athlete and for demonstration during training of other athletes. An example of such use is shown in Fig. 4.

References

1. Bilenko A.G., Govorkov L.P., Tsipin L.L. Izmereniya v biomekhanike fizicheskih uprazhneniy. Prakticheskiy kurs: uchebnoe posobie. NGU fizicheskoy kultury sporta i zdorovya im. P.F. Lesgafta, Sankt-Peterburg. SPb, 2010. 166 p.
2. Ovchinnikov Yu.D., Prokopchuk Yu.A. Biomekhanika dvizheniy v skandinavskoy hodbe. Fizicheskaya kultura. Sport. Turizm. Dvigatelnaya rekreaciya. 2017. No. 3. Pp. 43-47.

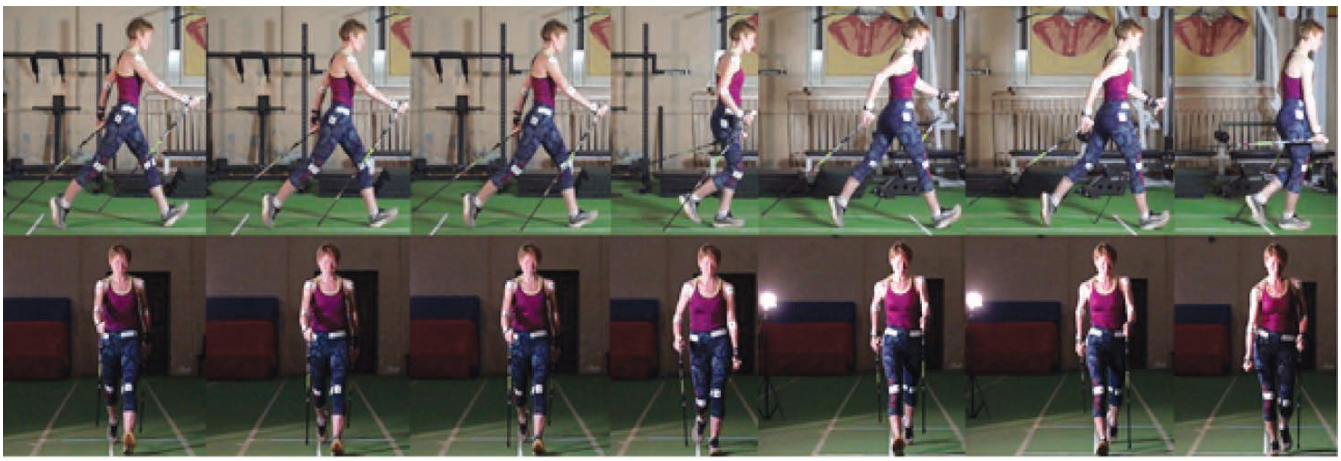

Fig. 4. An example of using multi-camera video footage of Nordic walking to demonstrate and study an athlete's technique

3. Samsonov M.A. Vybor aktualnogo ustroystva dlya videosyomki bystroprotekayushhih dvizheniy v fizicheskoy kulture i sporte. Trudy kaf. biomekhaniki: sb. statey. NGU fizicheskoy kultury sporta i zdorovya im. P.F. Lesgafta, Sankt-Peterburg. SPb. 2022. No. 16. Pp. 43-51.
4. Samsonov M.A. Osobennosti videosemki bystroprotekayushhih sportivnyh dvizheniy s uchetom «rollingshutter effekta». Trudy kaf. biomekhaniki: sb. statey. NGU fizicheskoy kultury sporta i zdorovya im. P.F. Lesgafta, Sankt-Peterburg. SPb. 2022. No. 16. Pp. 30-42.
5. Samsonov M.A. Rekomendacii po metodike videosyomki dlya korrektnoy obrabotki harakteristik sportivnyh dvizheniy cheloveka s ispolzovaniem programmy Kinovea. Trudy kaf. biomekhaniki: sb. statey. NGU fizicheskoy kultury sporta i zdorovya im. P.F. Lesgafta, Sankt-Peterburg. SPb. 2023. No. 17. Pp. 46-54.
6. Skripnichenko E.V. Skandinavskaya hodba kak universalnoe sredstvo polucheniya fizicheskoy nagruzki dlya studentov specialnoy medicinskoy gruppy zdorovya. OlymPlus. Gumanitarnaya versiya. 2020. No. 1 (10). P. 67-68.
7. Filimonov S.S., Vasenkov N.V. Skandinavskaya hodba kak kompleksnyy metod ukrepleniya zdorovya studentov tekhnicheskogo vuza. Tendencii razvitiya nauki i obrazovaniya. Samara. 2023. No. 97 (10). Pp. 100-103.
8. Dziuba A.K., Zurek G., Garrard I., Wierzbicka-Damska I. Biomechanical parameters in lower limbs during natural walking and Nordic walking at different speeds. Acta of Bioengineering and Biomechanics. 2015. Vol.17 (1). Pp. 95-101.
9. Pellegrini B., Peyré-Tartaruga L.A., Zoppirolli C., Bortolan L., Bacchi E., Figard-Fabre H. et. al. Exploring Muscle Activation during Nordic Walking: A Comparison between Conventional and Uphill Walking. PLoS ONE. journal.pone. 2015. Vol.10 (9). P. 13.
10. Roy M., Grattard V., Dinet C., Soares A.V., Decavel P., Sagawa Y.J. Nordic walking influence on biomechanical parameters: a systematic review. European Journal of Physical and Rehabilitation Medicine. 2020. Vol.56 (5). Pp. 607-615.