FAKULTA STROJNÍ
ZÁPADOČESKÉ
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V PLZNI

ERGONOMICS OF RUNNING AND TREKKING POLES
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ABSTRACT

The main goal of this work is to analyze ergonomic models of cross-country and trekking poles and to present suggestions for improvement of existing parameters. The aim is to maximize comfort while eliminating adverse effects on users. Partial goals of the work are as follows: improve the grip ergonomics, reduce the muscular load in the forearm and the possibility of grip modularity for different customer groups. Furthermore, there was a 3D scan of designs to improve the current grip with subsequent 3D printing. The influence of the new shape of the grip on the reduction of the forearm muscular load is demonstrated by the measurement of electromyography directly on the upper extremities of athletes.

KEYWORDS

EMG measurement, ergonomics, muscle load, poles.

INTRODUCTION

Muscle load can be recorded with EMG Holter, which allows recording with four EMG signals and possibly pulse frequency. This device provides one of the most sophisticated measurements of muscle weight at all. The instrument is connected to the computer by means of the EMG Analyzer software. In addition, EMG signals are analyzed throughout the measurement based on the maximum EMG values (Fmax) - all signals are normalized to Fmax. Based on a defined measured section, average signal values can be calculated, expressed as a percentage of Fmax. It is also possible to display a histogram (distribution) of normalized EMG values, which are also expressed as a percentage of Fmax. It was this device that was used as evidence of improved ergonomics and reduced muscle load when developing a new grip. [1]

ANALYSIS OF THE CURRENT CONCEPT

First, a 2D and 3D model of the current concept of running and trekking poles was created. These models were then used to simulate the grips of the poles in the software Tecnomatix Jack. 155 cm, 160 cm and 165 cm long poles were available for examination, with predefined athletes assigned to these lengths.
Poles length for skater man (25 - 45 Years):

- 185 cm height - hole 165 cm length,
- 180 cm height - hole 160 cm length,
- 175 cm height - hole 160 cm length,
- 170 cm height - hole 155 cm length.

The GERMAN Population data was used to create the simulation. The percentile heights assigned to the wands are shown in the figures below.

GERMAN 5th percentile, man, hole 155 cm

The height of the 5th percentile GERMAN Population was set as follows in Tecnomatix Jack. For each pole size, the collision between the palm and the fingers and between the pole was analyzed (the colliding elements would be shown in red), but they are not, the model of the hand was shaped a little from the pole because athletes have a glove around the palm. The Tecnomatix Jack model was not created by the real character. The standing position was selected as the base position.

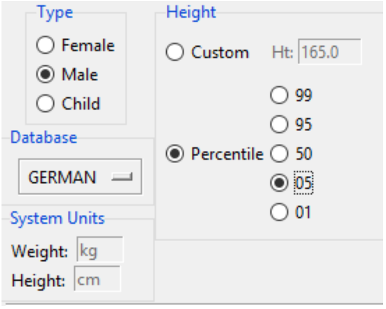

Figure 4: Male height 5th percentile

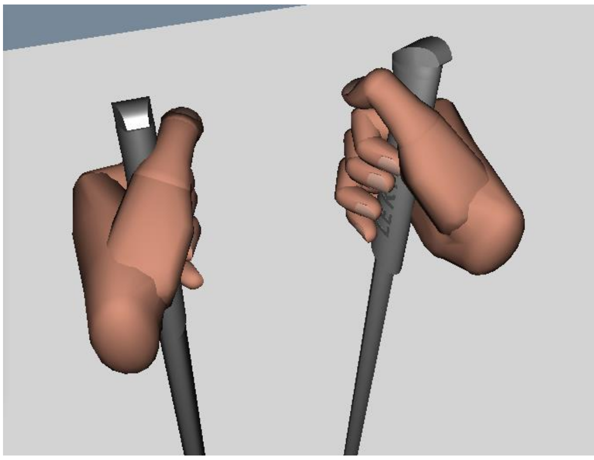

Figure 5: Male 5th percentile - TX Jack

In Tecnomatix Jack, we used the collision detection analysis between objects. It is obvious from the model that a man who falls into the 5th percentile with his palm cannot encircle the entire grip.

Comparison of 5th, 50th, 95th percentile, male

The following figure shows a comparison of all modeled handles. It compares the 5th, 50th, and 95th male percentiles. The picture shows the size differences of the hands and the problems that occur here. The 5th percentile grip size is too large. The 95th percentile grip is too small and collides with the palms of the palm.

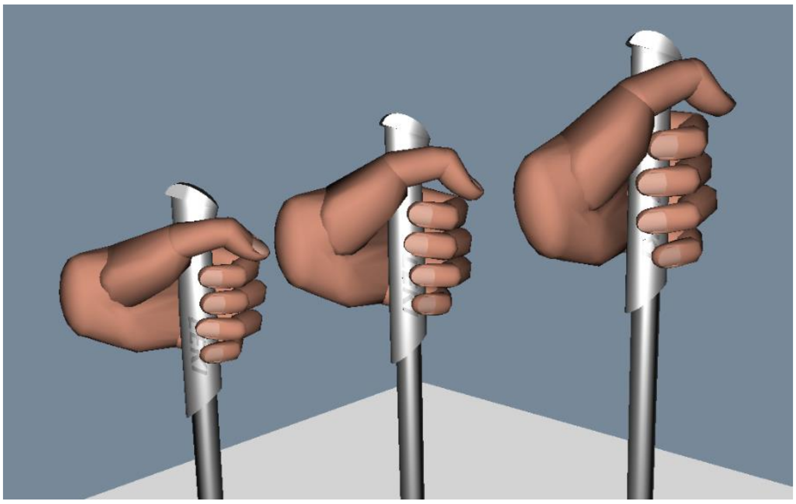

Figure 6: Hand and grip size comparison, man

In a similar vein, the Tecnomatix Jack software has also been used to solve individual situations for different heights of women. The results are very similar, the problem occurs women in the 5th and 95th percentile. This was the first project output, verifying all pole lengths in TX Jack software. [2]

EMG TESTING IN REAL CONDITIONS

Measurements of athletes took place on a remote route between Pilsen and Dobřany. Athletes were measured for 30min and drove about 9km. To test the muscles of the forearm muscles, we would use the EMG Holter device, which sets the categorization of work in the Czech Republic. But this device has a much wider use, not only for industrial practice. EMG Holter is one of the most accurate devices ever to detect the muscular activity of forearm muscles. [3]

Measurement of poles 160 cm, man
Date of measurement: 20. 8. 2018
Basic Athlete Data:

- Gender male
- Age: 30 years
- Height: 179 cm
- Weight: 74 kg
- Dominant Hand: Right
- Glove Size: 9
- Active cross-country skiing: 25 years

Basic Environmental Data:

- Place: Dobřany
- Length of measurement: 30 min
- Surface type: Asphalt
- Air temperature: 33 ° C
- Way of skiing: first half of skating, second half of running

Average measurement results
The % Fmax was about 17 % Fmax for the right forearm flexor muscle group, and about 11 % Fmax for the left forearm. For the right forearm extensor muscle group, the value is around 14 % Fmax, and about 19 % for the left forearm Fmax.

EMG	Current concept (% Fmax)
EMG 1	17
EMG 2	14
EMG 3	11
EMG 4	19

Table 5: Average values Fmax - pole 160 cm - Current concept

Ergonomic questionnaire data
The athlete felt pain WHEN doing sports - see the following figure:

Figure 7: Problem areas

Sportsman would like to add material under palm, approx. 5 - 8 mm. This was subsequently simulated with memory foam. The athlete had a blister between his thumb and forefinger after 30 minutes of skiing. He would prefer cork from the other side of the grip.

NEW GRIP SHAPE DESIGN

After analyzing and defining problem areas, athletes squeezed the grip with memory foam as they would like. These grips were then scanned with a 3D scan.

Figure 8: The memory foam and the 3D scan

First, the production of a brand new grip to be mounted on the poles was considered, but this was rejected for technical reasons. After the 3D scan, only the additions that were stuck to the existing poles with a special glue were modeled and the 3D printer printed. The result of the grip analysis revealed that it would be appropriate to choose to produce 3 different sized grips. The smallest poles do not need any extra. Poles medium (160 cm) need a smaller addition, poles largest (165 cm) a large addition. The additions were internally named S, M, L. All shown in the following figure, which depicts grips for medium and large poles. Part of the proposal was to work with all the information that the athletes said, so we also worked with a proposal where the allowance would not only be under the palm but also under the index finger. Subsequent EMG testing, however, only took place with new grips, where the grip was only under the palm of the hand, the index finger was disregarded because the athletes eventually found the innovation inappropriate.

Figure 9: Design of new grips

EMG TESTING WITH A NEWLY DESIGNED GRIP

Measurement of poles 160 cm, man

Date of measurement: 22. 10. 2018

Basic Athlete Data:

- Gender male
- Age: 30 years
- Height: 179 cm
- Weight: 74 kg
- Dominant Hand: Right
- Glove Size: 9
- Active cross-country skiing: 25 years

Basic Environmental Data:

- Place: Dobřany
- Length of measurement: 30 min
- Surface type: Asphalt
- Air temperature: 33 ° C
- Way of skiing: first half of skating, second half of running

Average measurement results

The % Fmax was about 9 % Fmax for the right forearm flexor muscle group, and about 9 % Fmax for the left forearm. For the right forearm extensor muscle group, the value is around 13 % Fmax, and about 16 % for the left forearm Fmax.

EMG	New concept (% Fmax)
EMG 1	9
EMG 2	13
EMG 3	9
EMG 4	16

Table 6: Average values Fmax - pole 160 cm - New concept

Questionnaire data after measurement

- The athlete felt more supportive in his palm.
- Requirement for narrowing the sides of the addition - production.

- Pleasant shape in the palm area.

The comparison of the EMG results with the original grip and the new grip is listed in the following table, the total run values are compared. These are the results of all four professional athletes. The main result of the comparison of EMG measurements is clear evidence of a reduction in muscle load. Approximately it is 15% reduction in muscle load. [4]

EMG (4 people)	Current concept (% Fmax)	New concept (% Fmax)
EMG 1	17	9
EMG 2	14	13
EMG 3	11	9
EMG 4	19	16
EMG 1	16	14
EMG 2	24	13
EMG 3	18	16
EMG 4	19	19
EMG 1	10	9
EMG 2	9	8
EMG 3	16	13
EMG 4	16	14
EMG 1	7	7
EMG 2	18	17
EMG 3	9	9
EMG 4	22	16

Table 7: Compare EMG results of original and new grip

CONCLUSION AND RECOMMENDATIONS

Within the project, the ergonomics of running and trail running poles were examined. Several shortcomings have been identified during initial investigation and testing. The area under the palm of the hand was found to be a problem area for running poles (lack of material - poles are very narrow for athletes), the area under the palm was found to be a problem area for trail running poles (lack of material - poles are very narrow) and a tape that she clutched and strangled her hands. After analyzing the existing grips, new grips have been designed, more specifically, additions have been proposed to pole to the existing grips.
The result of this innovation was a reduction in the muscular load of the hands and forearms. At the same time, athletes felt much more supportive in the grip area during skiing.

ACKNOWLEDGMENTS

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