Komparativní analýza běhu na lyžích volnou technikou a bruslení na kolečkových lyžích

The Comparative Analysis of Free Technique Cross Country and Skating on Roller Skies

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Abstrakt:

Od pradávna se lidé po sněhové pokrývce pohybovali na lyžích. V posledním století se běh na lyžích stává čím dál populárnějším zimním olympijským sportem, který se těší vysoké popularitě. Bruslení na lyžích je novou technikou běhu na lyžích, jež se dynamicky rozvíjí od 80. let 20. století, kdy vzniklo, do současnosti.

Předkládaná studie porovnává svalovou aktivitu při bruslení na lyžích a na kolečkových lyžích.

Byly sledovány tři základní styly bruslení na lyžích: oboustranné bruslení dvoudobé na pravou i levou stranu a oboustranné bruslení jednodobé. Pro sledování začátků významných aktivací a následných deaktivací bylo využito metody povrchové elektromyografie (SEMG).

Výsledky potvrzují domněnku, že kolečkové lyže jsou vhodným speciálním tréninkovým prostředkem pro běžce na lyžích. Největší rozdíly mezi fázovými posuny aktivace svalů byly nalezeny mezi bruslením dvoudobým na levou stranu na lyžích a na kolečkových lyžích.

Abstract:

The skiing is a very old human locomotion on the snow. During the last century, it has became very popular winter and Olympic sport, currently profiting from its great popularity among the public. New cross country skiing technique – skating – has been developing very dynamically since the eighties years of the 20th century.

This presented study deals with a comparison of muscles activation during skating technique on skis and on roller skis.

We studied three base styles of skating: V-1 on right and left side and V-2. The beginnings of important activation of the muscles on a right leg and their subsequent deactivation during one step cycle were measured with surface electromyography (SEMG).

The results confirm the idea that we can consider roller skiing as a special training device of cross country skiing. This is correct from the kinetic view as well as from the connection of muscles. The biggest differences in phase shifts of muscle unit activation were found between V-1 on left side during cross country skiing and roller skiing.

Klíčová slova: *Běh na lyžích, kolečkové lyže, elektromyografie, zapojení svalů*

Key words: *Cross country skiing, roller ski, electromyography, connection of muscles*

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INTRODUCTION

The new technologies in development of equipment and preparations of tracks created new disciplines that become very popular with spectators. The technique progress is related to this phenomenon.

The skating on skies (on Fig. 1-3) was accepted by FIS international rules as a second technique in this

Figure 1-3: *Cross country skiing - skating*

winter sport in 1985. So it took a big step after 1985 (Kvamme, B.; Jakobsen, V.; Hetlan, S.; & Smith, G., 2005). Skating technique is more economical and about 23 % faster than classical technique (Street, McNitt-Gray, & Nelson, 1986; Gerald & Brian, 1994). We must integrate physiological, biomechanical and technical factors to reach the highest speed. Skate technique allows selecting the most optimal variation for holding the highest speed. This chosen is made by racer according to the terrain and conditions on the track.

According to Gerald et al. (1994), the cross country skiers spend most of time during the competition in up-hill. In these parts, the V-1 is used. A one pole-push in one step is typical for V-1 technique (also called ‘‘paddling’’, ‘‘offset’’, ‘‘gear 2’’ and other names) is generally considered as an uphill technique and uses both poles in an asymmetrical and asynchronous pole plant combined with a skating stroke on one side but not on the other side (Kvamme, B.; Jakobsen, V.; Hetlan, S.; Smith, G., 2005).

V-2 is characterized by a double pole-push in one step (The phase of pole-push is short: it takes only 20 % of the course. The phase of glide is longer: 50 – 60 %). V-2 technique (also called ‘‘double dance’’, ‘‘one skate’’ and ‘‘gear 3’’) is usually viewed as a higher speed technique to be used under faster conditions on flat terrain or to maintain momentum over short uphills. It is a symmetrical skating technique utilizing a double pole plant with a skating stroke on each side (Kvamme, B.; Jakobsen, V.; Hetlan, S.; & Smith, G., 2005).

The roller skiing (on Fig. 4-6) is considered as one of the little special summer trainings for cross country

Figure 4-6: *Roller skiing - skating*

skiing. The techniques of skating on skies and on roller skies are according to empiric experiences of coaches and racers very similar.

METHODS

The most suitable method for monitoring the connection of muscles during the human locomotion in terrain is surface electromyography (SEMG) with synchronized video recording. This method is non-invasive and can be used out of laboratory (De Luca, C. J., 1993). This research was realized on very well prepared tracks in Pec pod Snezkou on the bottom of Cerna hora and on a dry road with compact asphalt surface under the Husova cottage.

We used a mobile device for EMG recording – ME 6000, providing 16 bit resolution and sampling frequency 2000 Hz. This device was carried on athlete´s body. The athlete was highly trained senior athlet of CZE cross-country skiing team. Her dominant push leg is left and she is right-handed. She prefers V-1 technique on right side.

This preliminary intraindividual study deals with two locomotion of cross country skiing: free technique (XC) on skies and roller skies (RS). We monitored V-2 step and V-1 step on right and left side on skies and roller skies. We measured every locomotion five times per 30 seconds. We evaluated 60 step cycles from each activity.

Analyzed muscles: m. gluteus maximus dx, m. gluteus medius dx, m. peroneus longus dx, m. tibialis anterior dx, m. gastrocnemius dx – caput medialis, m. rectus femoris dx, m. biceps femoris dx, m. adductor magnus dx, vastus lateralis dx, vastus medialis dx, m. obliquus abdominis externi dx, m. obliquus abdominis externi sin.

Acquired recordings were downloaded to PC and assessed using Mega Win and Matlab software. We prepared an algorithm for evaluation of acquired data. Using the signal from an accelerometric sensor, the algorithm segments the recording according to several periods of movement. Signals from all EMG channels were converted into absolute values and low-pass filtered using a FIR-filter (cut-off frequency 4,14 Hz, stop-band rejection –55 dB) to obtain EMG envelopes. Subsequently, in each of periods (according to the mentioned segmentation) we made detection of muscle onset and cessation. Used algorithm detects only one interval of muscle activity in each movement cycle. We prefer performing the detection of beginning and ending of muscle activity in each movement cycle separately rather than to work with the averaged EMG envelope that can cause lost of important information.

Threshold of definition of starting muscles activation and deactivation is +/– 10 samples at sampling frequency 1000 Hz (De Luca, C. J., 1993). During sampling at 2000 Hz, the limit of definition is +/–20 samples.

The results are presented as phase shifts of activation and deactivation of measured muscles during the step cycle.

This research was authorized by ethic commission from Faculty of Physical Education & Sport in Prague and the athlete was informed about problem.

RESULTS

Table 1 shows numeric values of phase shifts of muscle activation and deactivation, which are presented as graphs below (Figures 8-10). For better orientation in the table, we marked distinguishes and interesting features in connection of muscles on lower extremity during skating.

Duration of period of step cycle and limits of differentiability according to De Luca (1993) are as follows:

- XC V-1R: 1,51s: limits of differentiability: +/ – 1,51 %
- RS V-1R: 1,56s: limits of differentiability: +/ – 1,56 %
- XC V-1L: 1,54s: limits of differentiability: +/ – 1,54 %
- RS V-1L: 1,56s: limits of differentiability: +/ – 1,56 %
- XC V-2: 2,25s: limits of differentiability: +/ – 2,25 %
- RS V-2: 2,18s: limits of differentiability: +/ – 2,18 %

Muscles / Locomotion	Glut. max. dx	Glut. med. dx	Peroneus long. dx	Tibialis ant. dx	Gastroc. c.me. dx	Rectus fem. dx	Biceps fem. dx	Adductor mag. dx	Vastus lat. dx	Vastus med. dx	Ext.abdom. obl. dx	Ext.abdom.obl. sin
Activation												
XC V-1L	2.5	13.6	43.6	57.9	36.1	41.8	5.4	54.1	40.5	1.0	48.9	49.4
RS V-1L	4.4	15.9	71.4	62.4	46.1	41.5	8.5	60.2	47.2	4.7	53.7	49.0
XC V-1R	26.4	3.5	39.5	54.1	34.1	37.3	4.8	53.9	26.7	33.6	85.0	92.8
RS V-1R	18.6	5.3	44.8	51.8	28.8	34.1	58.0	44.4	31.1	32.5	92.9	92.5
XC V-2	38.6	86.5	43.6	56.5	43.7	46.6	4.4	55.4	37.1	39.5	31.1	70.1
RS V-2	40.1	35.1	43.9	54.6	43.1	45.7	63.3	49.9	33.3	40.5	26.3	68.7
Deactivation												
XC V-1L	32.0	46.6	70.1	2.3	65.9	78.3	30.1	86.7	65.3	29.9	83.8	83.0
RS V-1L	31.1	62.7	94.9	93.2	74.1	73.2	34.5	86.8	69.9	29.9	88.2	88.9
XC V-1R	59.9	55.4	67.6	98.4	63.8	70.4	37.3	84.0	59.0	58.6	26.8	35.1
RS V-1R	55.1	57.2	75.8	1.2	60.0	59.3	96.3	80.0	56.4	57.8	25.6	33.4
XC V-2	65.6	7.6	68.9	93.5	69.9	67.0	27.3	81.7	66.6	66.6	51.5	98.6
RS V-2	64.0	63.1	65.1	90.9	70.1	63.3	86.8	78.1	62.4	64.1	49.0	97.7

Table 1: *Average position of activation / deactivation of muscle activity (in % of step cycle).*

→ In this cells are marked only intralocomotion differences

} In this cells are marked the phase shifts which were evaluated together.

1	Gluteus maximus muscle R
2	Gluteus medius muscle R
3	Peroneus longus muscle R
4	Tibialis anterior muscle R
5	Gastrocnemius muscle - medial part R
6	Rectus femoris muscle R
7	Biceps femoris muscle R
8	Adductor magnus muscle R
9	Vastus lateralis muscle R
10	Vastus medialis muscle R
11	External abdominal oblique muscle R
12	External abdominal oblique muscle L

Figure 7: *Caption of measured muscles*

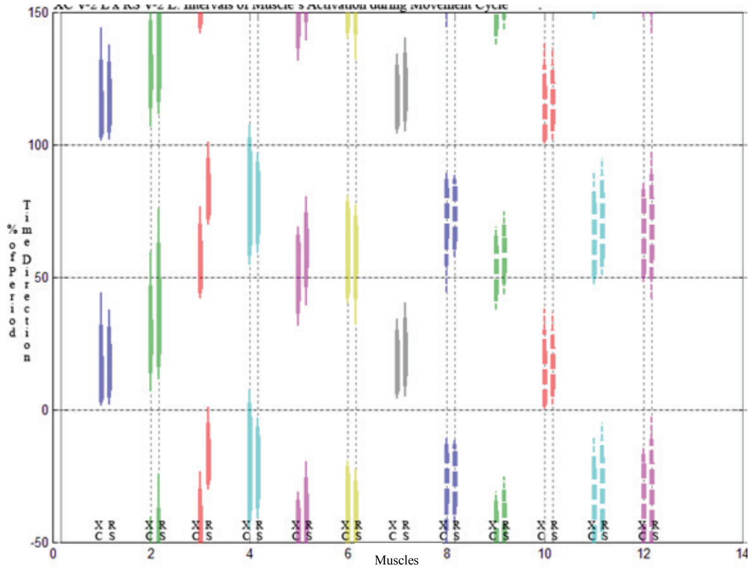

***Figure 8:** Comparison of phase shifts of measured muscles during V-1 on left side*

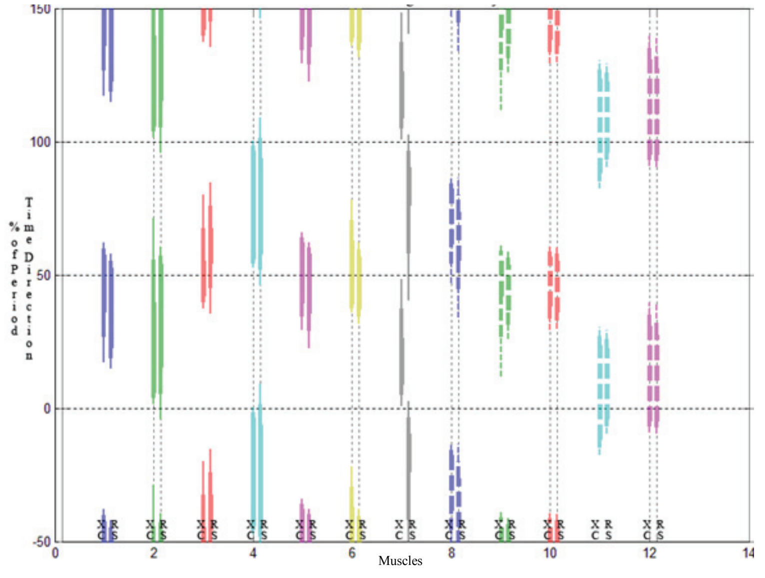

***Figure 9:** Comparison of phase shifts of measured muscles during V-1 on right side*

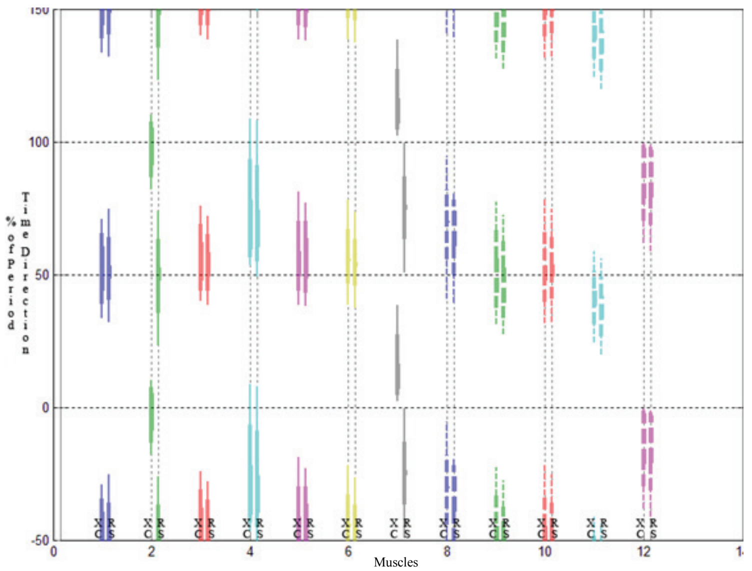

Figure 10: *Comparison of phase shifts of measured muscles during V-2*

DISCUSSION

In our opinion, the limits of differentiability determined according to De Luca (1993): +/– 10 samples at sampling frequency 1000 Hz, so in our case: +/– 20 samples at sampling frequency 2000 Hz, is too low for monitoring relatively variable locomotion like cross country skiing. For that reason we decided to set the bounds at 5 % as already different phase shift.

Averaged length of movement cycles during skating on skies and on roller skies almost corresponds in all measured modifications of the locomotion.

Interesting results were found at mm. obliqui abdominal external dx et sin. They are activated and deactivated almost simultaneously during V-1 (the right side subtly sooner – the athlete prefer skating on right side) but their reciprocal activation and deactivation are rearranged about half phase during V-2. This phenomenon is caused by double pole push during one movement cycle probably. During V-1 on right side, the right part of body is activated sooner while during skating on the left side, mm. obliqui abdominal external are activated at the same time.

A big difference of phase shift was found at m. vastus medialis dx and lateralis dx during V-1 on left side. M. vastus medialis dx is activated about 7 % earlier than m. vastus lateralis during V-1 on right side but during right side V-1 on roller ski, these are activated simultaneously. But caput medialis of m. quadriceps femoris dx gains part lateralis at about 39, 5 % during cross country skiing and about 42, 5 % during roller skiing.

M. tibialis anterior dx is active almost about 15 % longer during V-1 on left side on skies roller skiing. It could be explained as follows: snow mantle is more changeable then asphalt surface and there is more difficult to hold the dynamic balance. Its function is stabilization so it must be active for longer time. But this suggestion is contested by results of activation of this muscle during other two techniques of skating on skies and roller skies, when it is activated in the same phase of cycle. Our athlete prefers skating on right side and Véle (2006) assumes m. tibialis anterior dx as walking marker. We can presume the athlete had to wait for the right moment of kick of right leg by skating on roller skies. M. peroneus longus dx and m. gastrocnemius dx - caput medialis behaviour very similarly as m. tibialis anterior dx. Similar results in behaviour m. tibialis ant. were found by Chrastkova (2009). There were studied activation of leg´s muscles during a classical technique in cross country skiing. These muscle guarantees stabilization the foot in dorsal flex position. After the kick to tip of ski would not be place down on the snow early. Front-back stabilization and maintenance of dynamical balance are guaranteed by this muscle (Kmoch, 2011).

By confrontation of activation of m. peroneus longus dx we found a big difference of activation during V-1 on left side on skies and roller skies. By cross country skiing V-1 on left side, m. peroneus longus dx is activated much sooner (27, 8 %) than on roller skies. But during other two techniques of skating, the onset positions are similar.

We found a bigger difference among phase shifts in activation of m. biceps femoris dx. This flexor of knee join and extensor and abductor of coxa join is activated in the same time during V-1 on left side on skies and roller skies, but in the case of V-1 on right side on both kinds of skiing, it happened to delay the activation about more than 50 % than during roller skiing. This abnormality can be caused by athlete´s side preference (right side).

M. gluteus medius dx participates in locomotion V-1 on right side during cross country skiing and roller skiing in the same time. However during V-1 on left side on roller skies, it stays activated about 14 % of the cycle longer. This abductor and rotator of coxa join show a big difference (51 %) in activation during V-2. The duration of its activation is the same.

For skating on skis, the phenomenon of the triple extension of the pushing lower limb was described, and the stabilisation effect of m. gluteus medius was discovered for the pelvic region (Suchý & Kračmar, 2008).

M. gluteus medius and maximus are activated very similar. It is explained with its common function – leg abduction which is in motion during all movement cycle (Kmoch, 2011).

Divergences in activation of muscles between cross country skiing and roller skiing can be conditioned by different conditions for kick. Asphalt surface affords comfort space for kick compared to spring snow which is ideal ground to create a strong punctum fixum by the kick. The different synchronization of muscle activation among V-1 on left side and other two techniques of skating can be determined by season when our research was made. The stereotype of locomotion on roller skies is not established in full degree at cross country skiers in spring. Therefore, the muscles can activate in a different way on no preferred side compared to the preferred side.

CONCLUSION

The results of this study confirm that it is possible to consider roller skiing as a special training device for cross country skiing. Namely not only from the kinetic view but also from position of muscle activation and deactivation. The biggest differences in phase shifts of muscle unit activation were found between V-1 on left side during cross country skiing and roller skiing. Or else, our athlete was experienced cross country skier and her muscles activated in different synchronization during skating on non-preferred side on roller skies. We are not able to say if this synchronization is right or not, but it points to necessity of technique training not only on skies but also on roller skies. Coaches should teach their wards skating on both sides.

We recommend training on roller skies on a damp surface to imitate an unstable ground to make the punctum fixum for kick. But safety is necessary!

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