DIFFERENCES IN THE ACTIVATION OF SELECTED MUSCLES DURING SKIING WITH ONE AND TWO STABILIZERS IN HANDICAPPED SKIERS OF THE GROUP LW2

Petra Matošková, *Vladimír Süss
****Bronislav Kračmar, ***Milan Bílý**

Charles University of Prague,
Faculty of Physical Education and Sport
J. Mártího 31 162 52 Praha 6, Czech Republic
matoskova@ftvs.cuni.cz, *suss@ftvs.cuni.cz,
**kracmar@ftvs.cuni.cz, ***mbily@ftvs.cuni.cz

Abstract

In this paper we deal with individual case studies comparing the analysis of specific skills - skiing with unilateral above-knee amputation (group LW2). Monitoring of kinesiology content of selected muscle movement took place through a comparative analysis with qualitative analysis of video clip and the quantitative comparison of the electric potential of the selected muscles. The group consisted of three skiers, two men and one woman aged 22-30 years. In the time of the research skiers participated in competitions in downhill skiing disabled in the Czech Republic in category LW2. The results show a different activation of selected muscles in conjunction with one and two stabilizers. Greater muscle activity was found in conjunction with the use of one stabilizer.

Keywords: Skiing, handicap, EMG, stabilizers, LW2

Introduction

The turn on the inner ski edge with the use of both stabilizers

The skier starts the turn with a slight forwarding the inner arm with the inner stabilizer and a slight bending the standing leg in knee joint in sagittal level together with a slight knee bending inside the turn.

The knee bend of the standing leg increases to the turn top in the sagittal level and also slightly bends inside the turn. At the same time there is a significant trunk bend forward. The trunk bend inside the turn in the frontal level also increases to the turn top. The inner arm in shoulder joint moves backwards from the turn start to its top, that is to the skier's body in the sagittal level. In the frontal level the arm is either too close to the skier's body during the whole turn course or on contrary further from the skier's body. The arm significantly bends in the elbow joint to the turn top. From the turn top the standing leg starts to stretch in the knee joint, and knee and trunk return gradually over the ski. The trunk bend stays the same. The inner arm moves in the shoulder joint again slightly in front of the body, in the elbow joint it stays in the same position. The outer arm with the outer stabilizer copies the movement of the inner arm.

The turn on the outer ski edge with the use of both stabilizers

The skier's movement in the turn course is same as during the turn on the inner ski edge. There are only the following differences: there is greater trunks bend to the turn top, the inner arm with the inner stabilizer is moved more forward at the turn start and the arm in the shoulder joint in the frontal level is significantly closer to the body than it is in turns on the inner ski edge.

The turn on the inner ski edge with the use of inner stabilizer

The skier's movement during the turn course is same as the movement of the skier using both stabilizers. There is not such a significant knee bend of the standing leg to the turn top. The knee is on contrary more significantly bended inside the turn. There are greater body bends in the frontal level and there is not such a significant trunk bend. The inner arm in the shoulder joint moves in the frontal level further from the body. From the turn top there is a greater bend of the standing leg in the knee joint. The arm in the shoulder joint moves back to the body in the frontal level. The outer arm with the outer stabilizer is above the snow and its position is very individual during the whole turn course.

The turn on the outer ski edge with the use of inner stabilizer

The skier's movement is same during the turn course as during the turn on the inner ski edge. Only to the turn top there is a more significant trunk bend than in the turn on the inner ski edge (Matošková, 2006).The skier does not have such postural certainty on the outer ski edge as on the inner ski edge. That comes from the postural function of a leg

1 Used methods

1.1 Research methodology

The research was based on observing individual case studies analysing the specific skiing skills – in skiers with one side above knee amputation (group LW2

1.2 Observed sample

The group of skiers with one side above knee amputation consisted of three skiers, two men and one woman aged between 22 and 30 years. In the time of the research only these three skiers took part in national competitions in downhill skiing in the category LW2. All skiers took part voluntarily in the research and agreed with results publication.

1.3 Electromyography record

The basic method for measuring activation of muscle groups is the surface electromyography (EMG). We have done the surface measuring EMG in muscle groups working on the motor stereotype of walking and in muscles working during downhill skiing. That was completed by a simple kinematical analysis with the help of the time analysis of a video record. The surface EMG (SEMG) in the area of kinesiology measures the muscle activation, co-activation of muscle groups in the course of complex and selected movement, influence of load on muscle function, can observe the process of a therapeutic process, and the effect of movement load.

1.4 Observed variables

We have chosen the following muscles for observing differences between skiing with one stabilizer and both stabilizers: musculus gluteus maximus, musculus tensor faciae latae, musculus adductor longus, musculus tibialis anterior, musculus peroneus longus. With regard to the fact that all skiers had amputated left leg, all muscles were on the right side.

1.5 Time analysis

On the basis of the defined start and finish of unit analysis (determination of critical points) (Matošková, Süss & Zahálka, 2008), we have roughly judged the length of individual steps duration with the help of the time analysis of a video record.

- Synchronization of the EMG record with the video record

With regard to the difference between the patterning of the video record (25 Hz) and the EMG record (200 Hz), it was necessary to synchronize starts of analysis units in EMG measuring. After determining the comparing unit (of the test) we set the synchronized start of the analysis unit by auto-correlation (Konrad, 2009

- Data normalization

Regarding the reality that analysis units had different time length, it was necessary to normalize data by transferring them to the percentage time axis (Konrad, 2009). Transferring units to percents was realized through averaging data in the interval corresponding to one percent in every analysed analysis unit.

2 Results

2.1 Turn on the inner ski edge

Picture 1 show the turn start, critical point 1 (ski placed on the flat part) and critical point 3 (turn finish, ski placed on the flat part). Picture 2 presents the critical point 2 (ski place on the inner edge) and critical point 2 in the turn on the outer ski edge

Picture 1. Critical point 1 and 3 – turn with two and one stabilizer

Picture 2. Critical point 2 – turn with two and one stabilizer and critical point 2 in the turn on the outer ski edge

Further in the result part we will show examples of electrical activity in selected muscles. To keep the observed skiers anonymous we will mark skiers' results with letters A, B, C. In Detail results are discussed in the part of discussion. Results are shown in standardized graphs, data on the time axis (x) are shown in percents of the whole time, which was needed by the skier to realize the appropriate turn. Figure 1 shows electrical activity of muscles m. tibialis anterior dx. and m. adduktor longus dx., m.gluteus maximus dx. and m. tensor fascie latae dx in the turn course on the inner ski edge in the skier A and the figure 2 shows activity of the same muscles in the skier B.

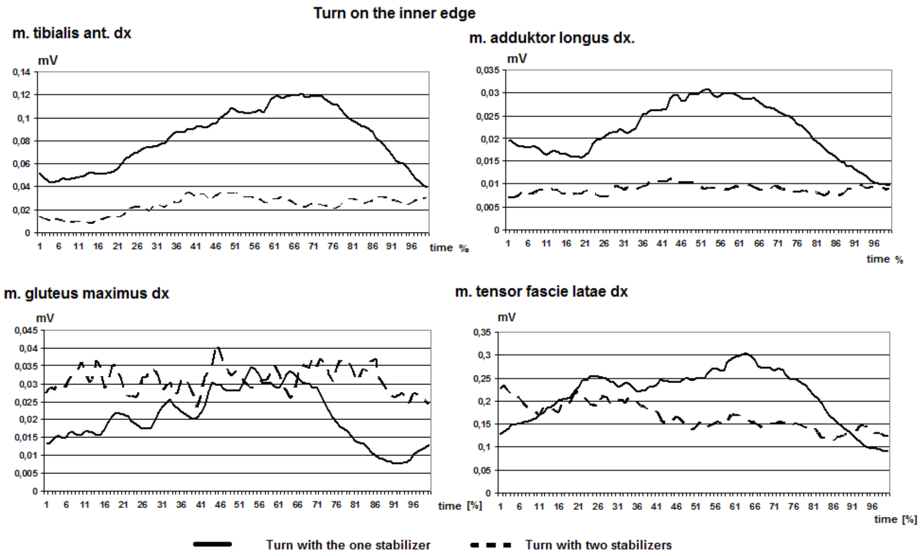

Fig. 1 Skier A Electrical activity of muscles m. tibialis anterior dx. and m. adduktor longus dx., m.gluteus maximus dx. and m. tensor fascie latae dx in the turn course on the inner ski edge

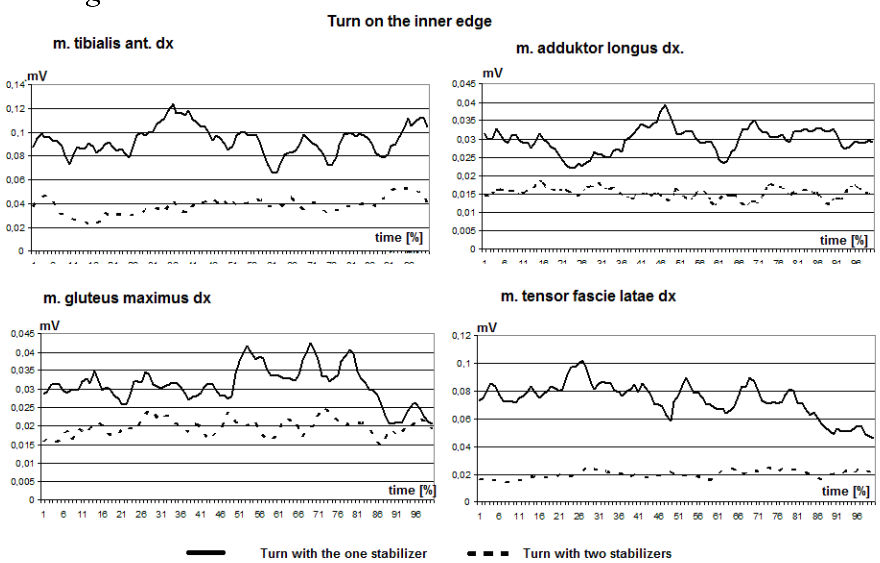

Fig. 2 Skier B Electrical activity of muscles m. tibialis anterior dx. and m. adduktor longus dx. m.gluteus maximus dx. and m. tensor fascie latae dx in the turn course on the inner ski edge

Skier C had in all four selected muscles similar realization as the skier B, therefore his figures are not stated here.

2.2 Turn on the outer ski edge

Results stated in figures 3 – 4 characterize activity of selected muscles during turns on the outer ski edge. Realization of this turn is recently enabled by the carving shape of the ski. In the past it was more difficult to realize this type of the turn.

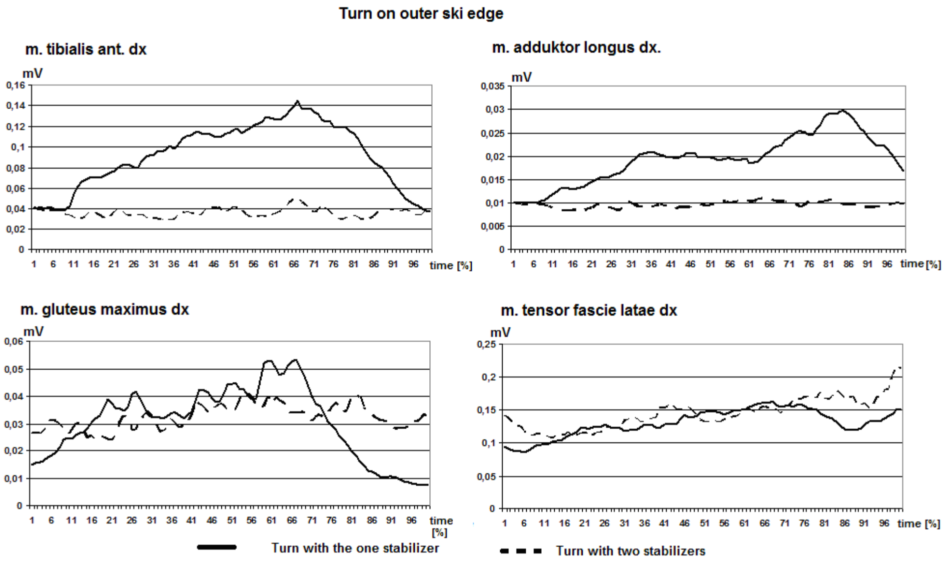

Fig. 3 Skier A Electrical activity of muscles m. tibialis anterior dx. and m. adduktor longus dx. m.gluteus maximus dx. and m. tensor fascie latae dx. in the turn course on the outer ski edge

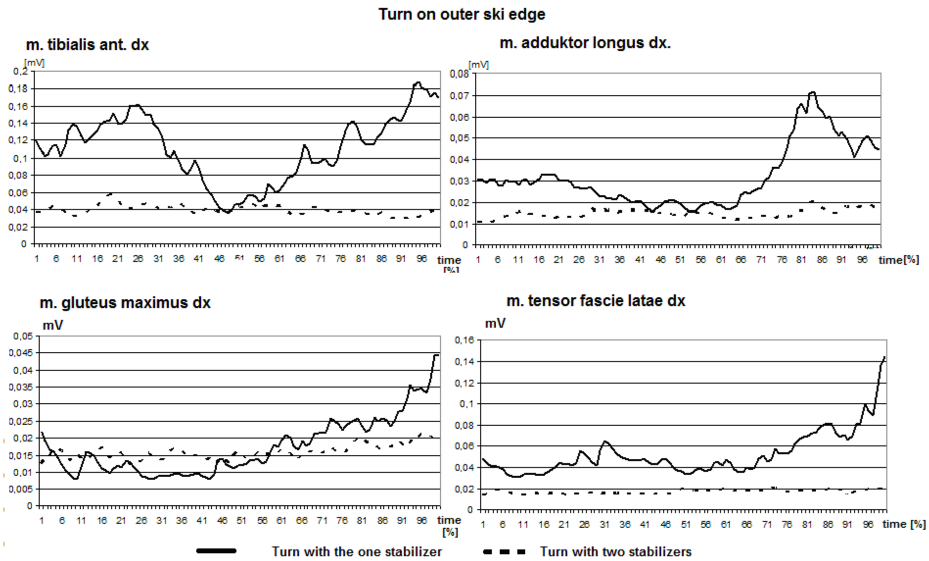

Fig. 4 Skier B Electrical activity of muscles m. tibialis anterior dx. and m. adduktor longus dx. m.gluteus maximus dx. and m. tensor fascie latae dx. in the turn course on the outer ski edge

Equally as in the turn on the inner ski edge we show results of skiers A and B, which are different. Results of the skier C are similar to results and the movement course of the skier B. Arguments are stated in the discussion.

3 Discussion

3.1 Turn on the inner ski edge with both stabilizers

During the turn course in the skier A activation of m. tibialis anterior, m. 154dductor longus (Figure 1) and m. peroneus longus is gradually growing before the turn top in 41% of the time (critical point 2). In the second part of the turn the electrical activity is decreasing. M. tibialis anterior reaches the curve top in 49% of the time, m. peroneus longus in 55 % of the time. A slight growth of activity comes in the turn top area in m. adductor longus in 43% of the time (critical point 2). M. gluteus maximus (Figure 1) has almost constant course of electrical activity during the whole turn course. M. tensor fasciae latae (Figure 1) has constantly declining electrical activity from the turn start in 0% of the time (critical point 1) up to the turn finish in 100% of the time (critical point 3).

Our results agree with literature in m. peroneus longus out of the observed muscles in the turn on the inner ski edge with both stabilizers. M. peroneus longus does leg eversion, is strongly activated when leaning the body forward (Dylevský, Druga & Mrázková, 2000). Its curve of the electrical activity reaches its maximum in 55% of the time. Here we come close to the critical point 2.

In skiers B and C is the activation of the observed muscles different (Figure 2).

Almost constant electrical activity of the observed muscles (Figure 2) appears during the turn course on the inner ski edge except for m. tibialis anterior dx. Differences in electrical tension can be explained by reaction to the interaction with snow during the turn course, than by the activity connected with the position change. These skiers do not reach performance of the skier A and in the skiing they use more support of the stabilizers. M. tibialis anterior dx. Decreases its activity at first and then slowly grows. This result corresponds with the growing shank lean during the turn.

3.2 Turn on the inner ski edge with one stabilizer

The muscles m. gluteus maximus (Figure 1) and m. tibialis anterior (Figure 1) are activated and the curve of the electrical activity is growing towards the turn top (critical point 2 – 52% of the time) during the turn course on the inner ski edge with one stabilizer in skier A. The electrical activity of the selected muscles significantly decreases to the turn end. M. gluteus maximus reaches its maximum in 55 % of the time, (critical point 2), and m. tibialis anterior in 68 % of the time. Muscles activation and the growth of the electrical activity curve towards the turn top and its gradual decreasing appears in m. adductor longus (Figure 1) and in peroneus longus. The curve of the electrical activity slightly decreases in m. adductor longus in the turn start, up to 20 % of the time. The highest activity is recorded in both muscles in 52% (m. adductor longus) and in 53 % (m. peroneus longus) of the time. The curve of the electrical activity of m. tensor fasciae latae has two tops; maximum is reached in 25 % and in 64 % of the time (Figure 1).

Our results agree with the literature in m. gluteus maximus, m. adductor longus and m. peroneus longus out of the observed muscles on the inner ski edge with one stabilizer. M. gluteus maximus initiates and keeps the pelvis lean and keeps so the upright body position; it ensures the lateral body stability. M. adductor longus stabilizes the middle segments of the lower limb during flexion in knee joint. M. peroneus longus does the leg eversion, it is strongly activated when leaning the body forward (Dylevský, Druga & Mrázková, 2000).

Similar course of the muscle work in this turn have m. gluteus medius, m. adductor longus with the curve tops in 52 % of the time, and m. gluteus maximus and m. peroneus longus with the curve tops in 55 % and 53 % of the time. They come close to the critical point 2, which lies in 50 % of the time.

The curve of m. tibialis anterior have similar course, the top is however reached in 68 % of the time.

Electrical activity of the muscle m.tensor fasciae latae (Figure 1) is different in comparison with the other muscles.

The activation course of muscles in the turn in skiers B and C is the following. M. tibialis anterior, m. adduktor longus, m. gluteus maximus and m. peroneus longus (Figures 2) have higher activity than in the turn with both stabilizers; the course of their activity can be marked as constant. Deviations from the average activity are small and we can talk rather about the posture stabilization and reaction to possible indicators during skiing than about significant changes caused by posture change. Exception is m. tensor facie latae; its muscle activity decreases (Figure 2) from the starting constant loading to the turn top (critical point 2).

3.3 Turn on the outer ski edge with both stabilizers

M. adductor longus and m. tibialis anterior have same course in all three skiers. Their intensity of electrical tension is almost constant (the course of the dashed curve in figure 3). A slightly growing character of the curve (figure 4) has m. gluteus maximus and m. tensor fasciae latae (with the exception to the skier B). The curve of m. gluteus maximus reaches its maximum in 54 % of the time, in the skier A and on contrary in the skiers B and C reaches its maximum in the critical point 3 (100% of the time). The curve of m. tensor fasciae latae is the highest to the end of the turn, in 98 % of the time (critical point 3) in skiers A and C. On contrary, a slightly decreasing character of the curve has m. peroneus longus with the top in 70 % of the time.

Our results agree with literature in m. tensor fasciae latae out of the observed muscles in the turn on the outer ski edge with both stabilizers. M. tensor fasciae latae does extension in knee joint, leans pelvis to the same side, contributes to the pelvis stability and is significantly activated during the stand on one leg (Dylevský, Druga & Mrázková, 2000). The curve of its electrical activity reaches maximum in 98 % of the time (critical point 3).

3.4 Turn on the outer ski edge with one stabilizer

During the turn on the outer ski edge with one stabilizer muscles are activated and the curve of the electrical activity is growing towards behind the turn top in m. adductor longus and m. tibialis anterior more distinctly in the skier A (Figure 3).

The intensity of electrical tension in the muscle is decreasing in the turn start in the skiers B and C, but in the second part of the turn the intensity is highly growing. Towards the turn finish the electrical activity of selected muscles is distinctly decreasing in all three skiers. M. adductor longus reaches its maximum in 80 % of the time, m. tibialis anterior in 68 % of the time in the skier A, on contrary to skiers B and C, when it reaches its top almost in 90 % of the time. M. peroneus longus is activated and its curve of electrical activity is growing towards the turn top in the skier A. The highest activity is recorded here in the 33 % of the time. The course of the electrical activity in the skiers B and C is different, after the starting decrease there is a growth of the activity up to reaching the critical point 2 to the level 75 % of the turn duration. The curve of electrical activity of m. gluteus maximus has two tops in the skier A (Figure 4) in 27 % and 67 % of the time, which corresponds to time closely before and after the critical point 2 (53% of the time). In skiers B and C there is a gradual growth of the intensity of electrical tension with the top in the critical point 3 (100% of the time). The double top curve and the gradual growth of the intensity of m. gluteus maximus indicate the activity of this muscle during the turn. Pelvis helps to stabilize and keeps the upright position of body. The course of intensity of electrical tension is growing in m. tensor fasciae latae and it reaches the highest activity in 100 % of the time, which corresponds the critical point 3.

Our results agree with literature in m. adductor longus, m. tibialis anterior and u m. peroneus longus out of the observed muscles in the turn on the outer ski edge with one stabilizer. M. adductor longus stabilizes the middle segments of the lower limb during flexion in knee joint. M. tibialis anterior does leg inversion and m. peroneus longus strongly activates during body leaning forward (Dylevský, Druga & Mrázková, 2000). All these activities are realized during the turn on the outer ski edge. A slight extension in the knee joint appears in the end of the end according to the kinematical description (Matošková, 2006; Matošková Süss & Zahálka, 2006); it is realized thanks to m. tensor fasciae latae. It proves the curve of electrical activity, (in all three skiers), which reaches its maximum in 100% of the time (critical point 3).

Conclusion

The study objectified in the terms of surface electromyography the presumption that skiers with amputated lower limb appear in different postural situation when skiing with one or both stabilizers. Validity is of course limited to the three observed tested persons.

It appears that skiing with both stabilizers loads less the healthy lower limb and can be recommended as a suitable motor activity for handicapped people. Skiing with using one stabilizer loads more the healthy lower limb and using this motor activity is recommended to better skiers. Skiing with one stabilizer is more demanding on the stability and coordination of movement from the didactics point of view (Matošková, Süss & Zahálka, 2006) and as it is more demanding on skier's fitness it confirms our opinion that it should be used by better skiers.In future research we recommend to connect the methods SEMG and kinematical analysis with measuring the power, which skier impacts on the ski and on stabilizers.

Acknowledgements
The project was supported by the Czech Republic's Ministry of Education, Youth and Physical Education MSM 0021620864.

Literature

[1] DYLEVSKÝ, I., DRUGA, R. & MRÁZKOVÁ, O. *Funkční anatomie člověka.* Praha : Grada Publishing, 2000.

[2] KONRAD P. *The ABC of EMG* a *Practical Introduction to Kinesiological Electromyography* [cit. 2009-07-25] Retrieved from www: http://reseau.risc.cnrs.fr/fichiers/apercu.php?numero=1.

[3] MACHAČ, J. *Komparace EMG aktivity vybraných svalů při chůzi a lyžování skupiny LW2*. Diplomová práce. Praha : UK FTVS, 2009

[4] MATOŠKOVÁ, P. *Deskripce specifické lokomoce lyžařů s jednostrannou nadkolenní amputací*. Disertační práce. Praha : UK FTVS, 2006

[5] MATOŠKOVÁ, P., SÜSS, V. & ZAHÁLKA, F. Pohyb lyžaře s jednostrannou nadkolenní amputací (LW2) v průběhu oblouku. *Česká kinantropologie,* 2006, no. 1, p. 125–135,

[6] MATOŠKOVÁ, P., SÜSS, V. & ZAHÁLKA, F. The movement of a skier with one above-the-knee leg amputation in the course of a turn. *Acta Universitatis Carolinae Kinantropologika,* 2008, vol 45, no. 2, s. 81 – 92,

[7] MATOŠKOVÁ, P., SÜSS, V. & KRAČMAR, B. Comparison of the muscle activity during the run with one or both stabilizers in handicapped skiers of the group LW2 *Acta Universitatis Carolinae Kinanthropologica,* 2010, vol. 46, no. 1, p.105-122,

[8] RODOVÁ D., MAYER M. & JANURA M. Současné možnosti využití povrchové elektromyografie. *Rehabil. Fyz. Lék.* 2001, no. 4, p. 173-177

PhDr. Petra Matošková, Ph.D., doc. PhDr. Vladimír Süss, Ph.D.,
doc. PaedDr. Bronislav Kračmar, CSc., PhDr. Milan Bílý

ROZDÍLY V AKTIVACI VYBRANÝCH SVALŮ U LYŽAŘŮ S JEDNOSTRANNOU NADKOLENNÍ AMPUTACÍ PŘI JÍZDĚ NA LYŽÍCH

V příspěvku se zabýváme porovnáváním jednotlivých případových studií analýzy specifické lokomoce lyžování – lyžařů s jednostrannou nadkolenní amputací (skupina LW2). Sledování kineziologického obsahu pohybu vybraných svalů se uskutečnilo formou srovnávací analýzy pomocí kvalitativního rozboru videozáznamu a na základě kvantitativního porovnání intenzity elektrického potenciálu vybraných svalů. Sledovaný soubor tvořili tři lyžaři, z toho dva muži a jedna žena, ve věku 22 – 30 let. V době výzkumu se pouze uvedení lyžaři zúčastňovali závodů ve sjezdovém lyžování tělesně postižených v ČR v kategorii LW2. Výsledky ukazují na rozdílnou aktivaci vybraných svalů při jízdě s jedním a se dvěma stabilizátory. Vyšší aktivita sledovaných svalů byla zjištěna při jízdě s využitím jednoho stabilizátoru.

UNTERSCHIEDE BEI DER AKTIVIERUNG AUSGEWÄHLTER MUSKELN VON SKIFAHRERN MIT OBERSCHENKELAMPUTATION

In diesem Beitrag befassen wir uns mit dem Vergleich einzelner Fallstudien in Bezug auf die Analyse von spezifischer Lokomotion beim Skifahren, im Einzelnen bei Skifahrern mit Oberschenkelamputation (Gruppe LW 2). Die Beobachtung der Kinesiologie der Bewegung bei ausgewählten Muskeln wurde in Form einer Vergleichsanalyse mit Hilfe einer qualitativen Analyse des Videos und aufgrund des quantitativen Vergleichs der Intensität des elektrischen Potentials bei ausgewählten Muskeln durchgeführt. Die untersuchte Gruppe bestand aus drei Skifahrern, zwei Männer und einer Frau im Alter 22 – 30 Jahre. Zur Zeit unserer Untersuchung haben diese drei Skifahrer an den Wettbewerben im alpinen Skilauf der Behinderten – Gruppe LW 2 – in der Tschechischen Republik teilgenommen. Die Ergebnisse zeigten eine unterschiedliche Aktivierung ausgewählter Muskeln bei der Fahrt mit einem Stabilisator bzw. mit zwei Stabilisatoren. Höhere Aktivität bei den beobachteten Muskeln wurde bei der Fahrt mit einem Stabilisator festgestellt.

RÓŻNICE W AKTYWACJI WYBRANYCH MIĘŚNI U NARCIARZY Z JEDNOSTRONNĄ AMPUTANCJĄ NAD KOLANEM PRZY JEŹDZIE NA NARTACH

Artykuł dotyczy porównania studia przypadków nawiązujacego do analizy specyficznego ruchu u narciarzy z jednostronną amputacją nad kolanem (grupa LW2). Obserwacja kineziologicznego zakresu ruchu wybranych mięśni prowadzona była w formie analizy porównawczej przy pomocy analizy jakościowej zapisów wideo oraz na podstawie ilościowego porównania natężenia potencjału elektrycznego wybranych mięśni. Badaniem objęto trzech narciarzy, dwóch mężczyzn i jedną kobietę, w wieku 22-30 lat. W czasie badań osoby te uczestniczyły w zawodach w narciarstwie zjazdowym osób niepełnosprawnych w Czechach w kategorii LW2. Wyniki wskazują na zróżnicowaną pracę wybranych mięśni przy jeździe z jednym i z dwoma stabilizatorami. Większą aktywność badanych mięśni stwierdzono przy jeździe z wykorzystaniem jednego stabilizatora.