JOURNAL OF OUTDOOR ACTIVITIES
Vol. 6, No. 1/2012, p. 5-18

MONITORING OF CHANGES OF THE INVOLVEMENT BY EMG IN THE AREAS OF PELVIC GIRDLE, SHOULDER GIRDLE AND BACK IN THE PROCESS OF WALKING AND NORDIC WALKING.

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Abstract

This study inquires into the changes of muscles involvement in particular areas of the human motion system in the process of walking and nordic walking at people in their older adulthood. Nine probands, aged 50 – 60, were field tested in order to detect differences of the motion system during labour. Our attempt was to discover specific differences in the involvement of selected muscle groups in the areas of shoulder girdle, pelvic girdle and lower limbs, and to find out similarities of coordination attributes in horizontal locomotion presented by the pardigm of crawling kinesiological content of Vojta´s principle. In the areas of selected muscles we carried out the intra-individual comparative analysis of the resemblance of pairs muscle activation by a modified formulation of two signals correlative function. Furthermore, we tested their activity on the basis of so called triangular detection of the signal with the consecutive comparation of these types of locomotion.

The results interpretation shows that during nordic walking there comes to the contralateral muscle connection between the lower body part and the shoulder girdle, which subsequently leads to the strengthening of these muscles and can be used as the prevention of vertebral column diseases or as a rehabilitation method. The shoulder girdle does not take over anti-gravity function, as it is at Vojta´s reflex crawling. It only takes part in the locomotion.

Key words: Electromyography (EMG), nordic walking, walking, Vojta´s principle, muscle chains

Souhrn

Tato studie prošetřuje změny chování zapojení svalů ve vybraných oblastech pohybové soustavy člověka při chůzi a nordic walking u jedinců starší dospělosti. Ke zjišťování těchto rozdílů v práci hybné soustavy bylo v rámci terénního testování změřeno 9 probandů ve věku 50 – 60 let. Snaha byla nalézt určité diference v rámci zapojování vybraných svalových skupin v oblasti pletence ramenního, pánevního a dolních končetin a nalezení podobností koordinačních atributů u lokomoce v horizontále předloženou paradigmatem kineziologického obsahu reflexního plazení u Vojtova principu. U vybraných svalů byla provedena intraindividuální srovnávací analýza podobnosti aktivace dvojic svalů na základě upravené formulace korelační funkce dvou signálů a dále byla zjišťována jejich aktivita na základě tzv. trojúhelníkové detekce signálu s následnou komparací těchto typů lokomoce.

Z interpretace výsledků je zřejmé, že při NW dojde ke kontralaterálnímu svalovému propojení spodní poloviny těla s pletencem ramenním, čímž následně dochází k posilování těchto svalů, čehož se dá využít jako prevence vertebrogenních potíží nebo jako součást rehabilitace. Pletenec ramenní při NW nepřebírá antigravitační funkci, jako je tomu u Vojtova reflexního plazení, ale pouze se do lokomoce zapojuje.

Klíčová slova: Elektromyografie (EMG), nordic walking, chůze, Vojtův princip, svalové řetězce

Introduction

Walking, as a one of basic human locomotions, goes through relatively significant changes from the point of view of phylogenetics. Several publications dealing with these themes (e.g. Dean, 1981; Jarvik, 1980; Krobot, 2004; Vančata, 2005; Richmond, Jungers, 2008 aj.) provide us with some interesting findings about these processes. There is a description of an individual from original vertebrates and chordates that live only in water up to animate beings evolutionary adapted to the onshore environment. They gradually turn through the morphological limb conversion from right-left wave motion in water into quadrupedal[1] motion model and further into the current form of bipedal locomotion which compared to quadrupedal manner develops relatively later. From the point of view of human ontogenetic developement, the quadrupedalism appears in its early stage which in fact goes back to this type of locomotion and exploits particular locomotional programmes of that age stage, but are covered by manipulation and holding functions in the course of the period (Véle, 2006, Kováčiková, 2008; Boonyonga, et. al, 2012 aj.).

This re-acquisition of particular programmes of quadrupedal locomotion, acquired in the phylogenetic developement proces, is used by Vojta (Vojta, Petters, 2005). Vojta makes use of this method of motional patterns recollecting within reflex locomotion to treat people with motor dysfunctions and creates his therapy used up to this day. According to Kračmar(2002), this idea has been taken over by sport locomotion researchers and several studies have been made (Novotný, 2007; Srbková, 2006; Herdová, 2009; Tlašková, 2007; Chrástková, 2009). Some similarities between Vojta´s principle of reflex crawling and different sport locomotions using upper limbs to move forward (e.g. cross-country skiing, paddling, nordic walking) have been found out. These studies also point out the problematics of chaining muscles which do not work individually but work together in a muscle chain. This is dealt by Véle (2006) and also later in this study.

Besides walking, the selected and observed locomotion is a quite new sport activity – nordic walking. Nordic walking, otherwise walking with sticks, i sone of the sport activities that have been recently enjoyed all over the world mostly by people in advanced age. Many authors dealing with the topic (e.g. Church et. al, 2002; Vystrčil, 2004; Ainslie et al., 2002, aj.) positively evaluate nordic walking physiological responses to body´s physical load during which some processes take place e.g. blood pressure improvement, heart rate increase with more intense fat metabolism and others. Also, the body weight is spread into more muscle areas (mainly shoulder girdle, back and upper limbs) and unwanted joint strain is reduced. On the other hand, there are studies contradictory to the ones mentioned above (e.g. Jacobson, 2000; Duckham, 2009), stating that changes between walking and nordic walking do not occur.

This work´s intention is a contribution to this problematics solution by observing particular muscle areas during walking and nordic walking by means of electromyograph (EMG) of muscle aktivity. This method is currently used as an objective tool in the proces of looking for used, easily accessible and the most precise method used for field testing of muscle activity in vivo. The EMG method and its assessment is dealt by many authors (DeLuca, 1997, 2001; Konrad, 2005; Hug, 2011; Pánek, 2009; DeLuca, 2001; Véle, 2006 and others).
The research target group consist of people in their mid-adulthood. The reason for this subpolation is that nordic walking is generally labelled, perceived and primarily recommended as a safe physical activity for this, or even older, age group.

This study monitors differences of individual muscles involvement during two types of locomotion (walking and nordic walking). The results show fundamental differences of these muscles in the whole muscular system working with respect to their time activation and activity.

Problem

Nordic walking is a type of locomotion realized not only by lower limbs, but also across newly formed punctum fixum on an upper limbs by shoulder girdle. Primarily, we wanted to find out if and how the changes of muscle activity in shoulder girdle occur during upper limbs, upper body and pelvis involvement in comparison to simple bipedal walking. Secondly, we intended to look up coordination attributes similarities of horizonatal and vertical locomotion when it is presented by the pardigm of crawling kinesiological content of Vojta´s principle.

The goal is to observe the changes of muscle involvement in particular areas of muscular system at mid-aged individuals.

Methods

Intra-individual comparative analysis of step cycle during walking and nordic walking. Both motional activities are monitored with surface polyelectromyography (EMG) with synchronized video recording. Mobile EMG device specifications:

Portable polyelectromygraphy data logger of muscles´ electric potentional - Megawin Biomonitor ME 6000 (Meg Electronics, Finland)
Technical details: signal raw/averaged/RMS/integrated with the range +/- 8192 μV for EMG, number of channels: 4/8/12/16, sampling rate: 1.000 / 2.000 / 10.000 / 250 / 100 Hz.

Group characteristics

The tested sample was chosen intentionally on the grounds of accessibility. It consisted of 9 probands (5 men, 4 women) aged 50 – 60 who were accustomed to walking with sticks. Thus, we minimized possible measure error caused by inappropriate walking technique. The age group was chosen because the fact that nordic walking is primarily recommended and percieved as a safe physical activity for those in mid-adulthood or older.

The testing was done outdoor with identical conditions during August 2011. Each individual was tested 6 x 30 sec during both locomotion types. The data from first three tests were considered as training and therefore were not evaluated. More tests were not called for in order to eliminate fatigue. Between two consecutive tests there was a compulsory 5-minute break. Pace was set to 4,75 km/hod for walking and 5 km/hod for nordic walking, and controlled with a metronome. According to Korvas et al. (2010), we can assume differences in muscular system workings even at these paces.

The monitored muscles had been choses with regard to their basal functions, as stated in a work by Čihák (2001), Travell, Simons (1999), and their functions during quadrupedal locomotion Čápová (2008) and their engaging in muscle chains according to Véle (1995, 2006). Prior to electrodes application, the skin had been cleaned, degreased with alcohol and shaved. The electrodes were placed in the manner that their centres´ connecting line ran in direction of muscle fibres in the spot of the highest, and physioterapheutically evaluated muscular tonus according to Travell, Simons (1999) during the simulation of assessed locomotion.
Monitored muscles:

1. M. latissimus dorsi dx., pars transversa
2. M. trapezius dx., pars descendens
3. M. deltoideus dx., pars acromialis
4. M. deltoideus dx., pars scapularis
5. M. gluteus maximus sin.
6. M. serratus anterior dx.

The complex analysis was processed with MegaWin software, inclusive of synchonization and video recording. Rough record of motion (raw signal) with sampling rate 1000 Hz was subsequently rectified and converted into absolute values (Konrad, 2005). From such modified signal, ten consecutive step phases were selected (10. – 20. steps). Intra-individual comparative analysis was based on adjusted formulation of correlative function of two signals, as recommended by Hojka et al. (2010) and was used for the evaluation of similarities of muscle pairs activaton based on Spearmen´s correlative coefficient. To establish time shift of muscle activation start with the following intra-individual and inter-individual analysis of selected parts, we applied so-called triangular detection of the beginning and the end of the aktivity which is currently used as the most precise method (Špulák, 2012). The values of muscles´ involvement were detected with script editor in programming environment Matlab (version 7.8.0, R 2009 a). Rough digital signal EMG was fully rectified by means of low frequency filter (cut off frequency 3.6 Hz, FIR order 501). Because of different durations of motion and probands´ better comparison, the time axis was expresses as a percentage, as suggested by (DeLuca, 1997; Hug a Dorel, 2009; Konrad, 2005; Foissac et al., 2008). The motion timing was used for the cinematic analysis. It was based on the analysis of lower limb step (LLL-left lower limb): bounce – swing phase – tread LLL – stand phase LLL.

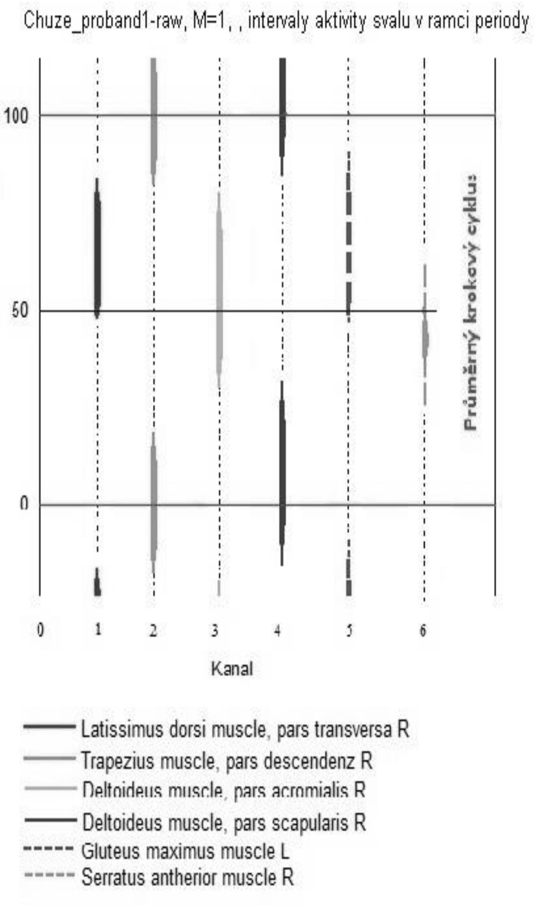
Results and discussion

Because of large amount of data, only one proband´s charts and data are shown in this part.

Fig. 1 Sequence of step cycle of proband nr.1 during nordic walking and walking (bounce –swing phase –tread – stand phase)

Fig. 2 Muscle activity intervals during walking and nordic walking

The names of muscles according to SW Matlab (verze 7.8.0, R 2009 a)



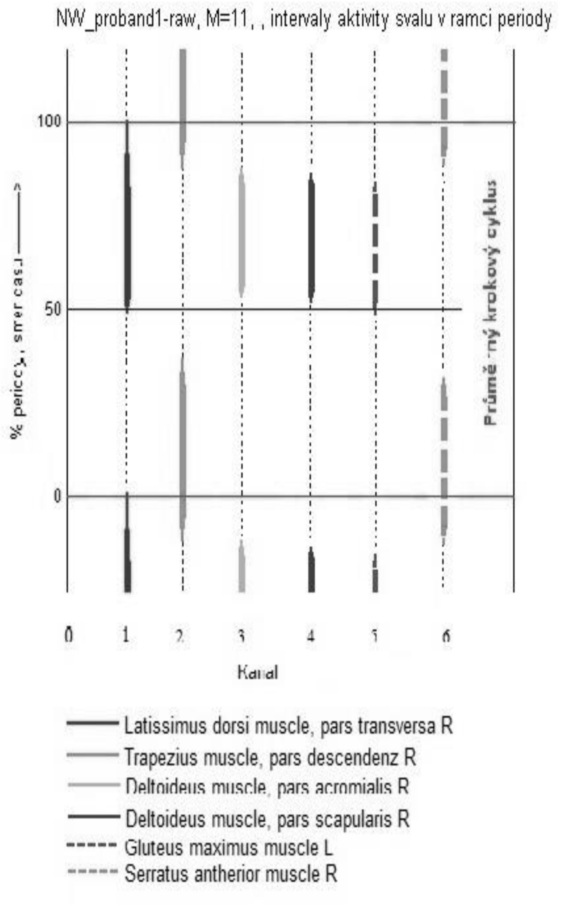


Table 1 Maximal muscles correlation during NW

	M. lat. dorsi dx. , p. transversa	M.trapezius dx., p. desc.	M. deltoideus p. acromialis, dx.	M. deltoideus p. scapularis.dx.	M.gluteus max., sin.	M. serratus ant.
M.lat.issimus dorsi	1	0,336	0,6	**0,817**	**0,768**	0,157
M.trapezius	0	1	0,106	0,247	0,149	0,354
M. deltoideus p. acrom.	0	0	1	**0,784**	0,453	0,118
M. deltoideus p. scap.	0	0	0	1	0,68	0,123
M.gluteus max.	0	0	0	0	1	0,197
M. serratus ant.	0	0	0	0	0	1

Table 2 Maximal muscles correlation during walking

	M. lat. dorsi dx. , p. transversa	M.trapezius dx., p. desc.	M. deltoideus p. acromialis, dx.	M. deltoideus p. scapularis.dx.	M.gluteus max., sin.	M. serratus ant.
M.lat.issimus dorsi	1	-0,178	0,249	0,239	0,471	0,128
M.trapezius	0	1	0,486	0,092	-0,212	0,015
M. deltoideus p. acrom.	0	0	1	0,606	0,092	0,03
M. deltoideus p. scap.	0	0	0	1	0,257	0,044
M.gluteus max.	0	0	0	0	1	0,079
M. serratus ant.	0	0	0	0	0	1

Fig. 3 The course of EMG signal of average step cycle (n=10) during nordic walking and walking (time position normalized to percentage due to better comparison)

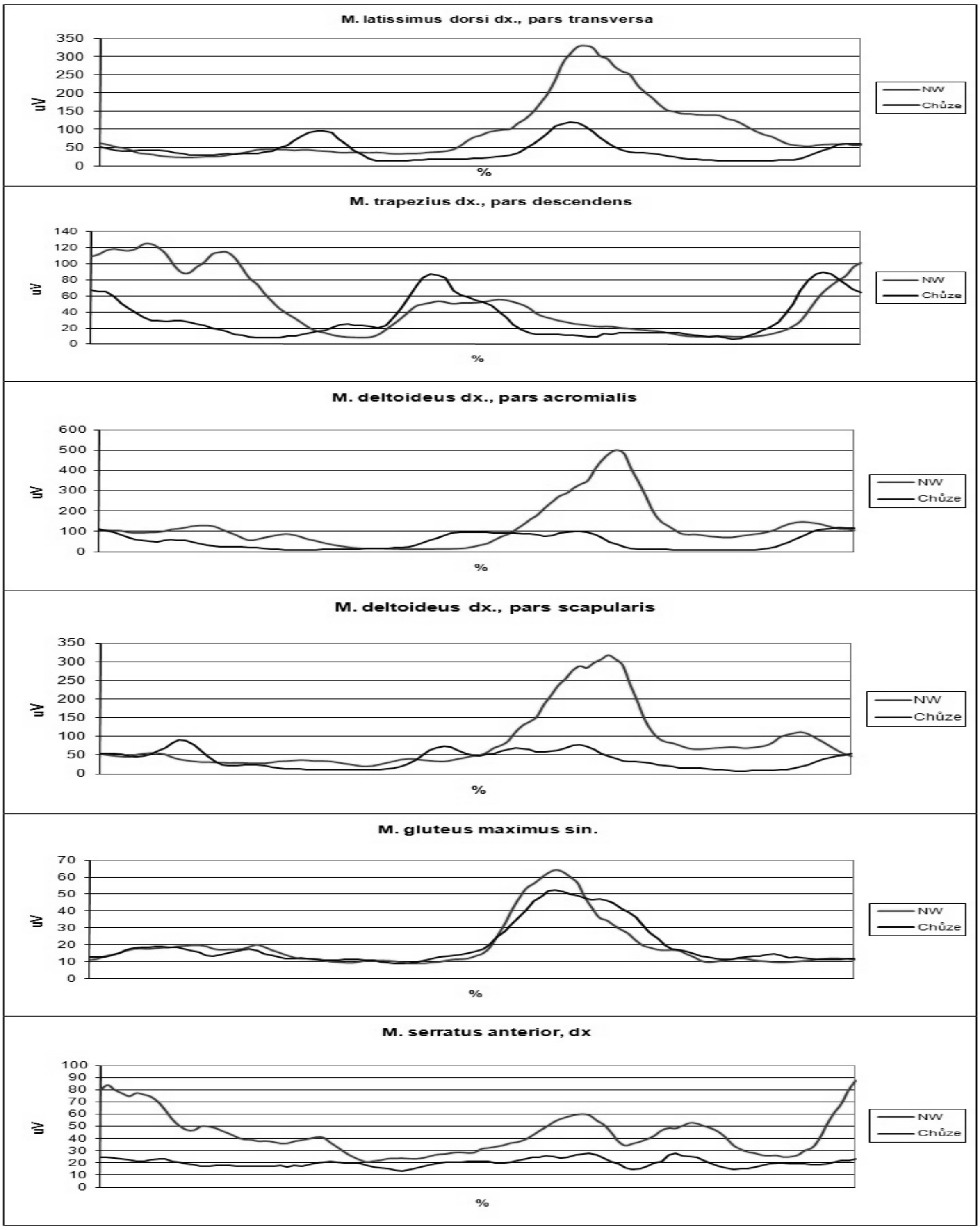


Table 3 Intra-individual comparison NW and walking based on values under EMG curve of average step (related to values under the curve during NW = 100%)

	M. lat. dorsi dx. , p. transversa	M.trapezius dx., p. desc.	M. deltoideus p. acromialis, dx.	M. deltoideus p. scapularis, dx.	M.gluteus max., sin.	M. serratus ant.
Proband 1	42,36%	69,18%	38,39%	43,98%	100,57%	48,03%
Proband 2	18,79%	81,54%	39,07%	45,24%	84,58%	31,79%
Proband 3	73,37%	64,08%	36,21%	25,67%	92,73%	67,69%
Proband 4	77,47%	40,66%	42,71%	44,50%	94,09%	16,49%
Proband 5	64,79%	87,70%	54,95%	29,88%	76,72%	97,12%
Proband 6	28,12%	44,79%	14,61%	21,44%	73,55%	32,16%
Proband 7	70,57%	77,22%	38,14%	28,19%	72,91%	86,08%
Proband 8	112,29%	146,80%	24,60%	47,87%	107,41%	52,98%
Proband 9	53,59%	58,86%	30,57%	41,20%	82,78%	22,54%
Průměr	60,15%	74,54%	35,47%	36,44%	87,26%	50,54%
SD	0,267	0,295	0,107	0,094	0,115	0,266

The results show some general facts. In recorded values and signals of muscle aktivity during two types of locomotion, there are trends or changes of muscle involvement activation based on different types of activities. Based on calculations and visual comparison of EMG data of individual types of locomotion and probands, we may state that at the locomotion with sticks there is more obvious start, development and continuity of EMG signal in shoulder girdle muscles. The signal seems to be more bordered with clearer starts of individual muscle activations than those of walking where the activation starts are not so prominent. Generally, this phenomenon occurs in shoulder girdle muscles when a stick supports the upper limb, thus creates closed kinematic chain and new punctum fixum on its acre. It is the moment when contralateral left leg is in tread phase and the body is carried forward to the second punctum fixum on the acre of the left upper limb. Another mutual trend, found at all probands, is similar activation of lower limbs and pelvis muscles. It is m. gluteus maximus sin. This muscle shows similar curves during bipedal walking and nordic walking. We studied mainly the extent of its involvement, so called muscle timing.

Based on the results, we looked for certain trends of muscles involvement and whether their activation happens in similar way or not. We focused mainly on correlation values of two muscles which exceeded 0,7 (see tab. 1 and tab. 2 – red). These muscles can be called as muscles with the high degree of association (Hendl, 2004), and are activated almost at the same time. This co-operation is present only during NW at all probands in m. latissimus dorsi dx. which is dominant muscle ensuring locomotion in this area. This muscle is engaged in the phase when left lower limb is ahead, the right leg in the bounce phase, and upper limbs in contralateral motion. Similar muscle´s activities are present in Vojta´s principle. This muscle activation appears in both types of locomotion, but during NW the activation starts with right upper limb in semiflection with stick support. This is manifested by the increase of the area under the muscle activity curve. Another ones whose values of correlation coefficients are high are ipsilateral muscles which points to the co-operation between shoulder and pelvis girdles. From the time activation point of view, we can say that they cooperate more often during NW which is shown in the correlation coefficient with the high association rate of curve. For that reason, we can assume that unlike walking where the values are lower in all cases, there is the cooperation and fixation of shoulder joint when the upper limb is supported by a stick during nordic walking. Based on the results we can say there is increased work load of these muscles during nordic walking. It is also demonstrated in charts with the course of average step cycle and by percentage intra-individual comparison of areas under this step curve and the area acquired during nordic walking which means considerable difference of these muscles involvement during two types of locomotions, as is shown in Tab. 3. Significant differences in areas under the curve can be seen at latissimus dorsi which also means its higher activity, work load and resulting strengthening.

We included gluteal muscle to find out if any changes in pelvis area occur during upper limbs employment. According to Véle (2006), M. gluteus maximus is a part of a long chain which is attached across latissimus dorsi and shoulder girdle to the contralateral upper limb. As far as the correlation of muscle curve course, there was noticeable similarity as is shown in charts of muscle activation or average step cycle. This muscle, functionally called as an extensor against femur and pelvis (Travell, Simons, 1999), acts during both types of locomotion in the second phases of step cycle, i.e. in extension phase when the center of gravity is shifted forward through this limb. This muscle engagement, when the upper limb is supported with a stick, is slightly lower at all probands, but this decrease is not significant and can not ascribed to the activities of upper limbs.

One of the main functions of pars descendens m. trapezius is shoulder girdle elevation. The second mentioned muscle is important for the position of shoulder joint socket and scapula (Travell, Simons, 1999). In Vojta´s principle the activity of the upper part of the trapezius is attributed to the forward motion of an upper limb, i.e. mutual activation with m. serratus anterior. This muscle cooperation should move the lower angle of scapula in lateral, cranial and ventral direction (Vojta, Peters, 1995). Based on these findings, previously published studies (Kračmar, 2002; Tlašková, 2007; Srbková, 2008; Novotný, 2007) and set hypotheses, we anticipated such a co-activation during our testing. However, this co-activation, similarily to long heads of arm muscles, did not occur (correlation timing of these muscles is within 0,1 – 0,3). Because of frequent timing diversification in these muscles involvement, we believe that theie main function during nordic walking is to balance unevennes caused when an upper limb is supported with a stick, and which makes these muscles rather non-pattern, as Tichý (2010) claims. It functions likewise during walking, but the involvement is smaller.

Conclusion

Based on the findings, it can be stated that during NW there occurs considerable percentage increase of muscle activity in back and shoulder girdle muscles. It is a positive finding which could be later used in vertebral column disesases therapy. The results interpretation also shows that during NW there is a contralateral muscle connection between the lower half of the body and the shoulder girdle, which strenghtens this muscle chain due to the upper limbs engagement in locomotion. Furthermore, we can state that there are not the same findings during locomotion with sticks as in Vojta´s reflex crawling. Based on the findings, NW can not be described as a quadrupedal locomotion in vertical, but only as a locomotion exploiting this quadrupedal pattern. The shoulder girdle does not take anti-gravity function during NW, it only takes part in it.

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