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MUSCLE ACTIVITY OF THE TRUNK AND UPPER LIMBS IN RACE WALKING

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ABSTRACT
Race walking requires high technical mastery of competitors based on biomechanical laws. These, in turn, are the basis of high sports results and effective techniques. Research in this direction mainly focuses on the work of the lower extremities. From this point of view, this study aims to determine the muscle activity of selected muscles on the upper body during race walking. The method of study is surface electromyography of the following muscles: m. Erector spinae longissimus; m. Rectus abdominis; m. Obliquus externus abdominis; m. Musculus trapezius (middle part); m. Pectoralis major; m. Lattissimus dorsi; m. Deltoideus anterior & m. Deltoideus posterior) front and back heads. Results: The most significant activation for the persons studied to exhibit m. Trapezius transversalis (65,49%) m. Latissimus dorsi (49,41%) and m. Deltoideus posterior (47,91%). Conclusions: the competitors' different technical skills differentiate some muscle activities, which will inevitably lead to different biomechanical expediency of the movements; The main direction in work should be to the muscles along the back of the trunk: Trapezius Transversalis, M. Latissimus dorsi, and m. Deltoideus posterior.

Key words: biomechanics, technique, muscle work

INTRODUCTION

Race walking as a discipline in athletics is associated, on the one hand, with the high level of development of aerobic capabilities and, on the other, with several technical requirements arising from the TR-54 rule.

The main focus of research in race walking is the movement of the lower extremities, especially the knee joint. The latter takes a large part of the load during a race, because the supporting leg serves as a lever through which the body passes to move forward. This, in turn, places a particular emphasis on the preparation of athletes in race walking.

Regardless of this directivity, we must remember the balancing function of the upper limbs, which using cross-coordination, allows movements to be performed without large deviations in the lateral direction. The movement of the upper limbs and the shoulder girdle have a flywheel character and move in the opposite direction of the corresponding limb. In this way, the twisting movement of the body around the vertical axis (in the frontal plane) is reduced.

As is well known, when turning the pelvis is within 20-24°, it automatically follows that the arms and shoulder girdle must move in such a way as to compensate for this rotation to maintain the forward movement of the body (1). The maximum rotation of the pelvis is at the toe off moment. The importance of this pelvic movement is further emphasized by the fact that, according to experts, a more significant rotation would lead to a greater stride length and a higher movement speed (1-5). All this is due to the significant dependence on the movement speed of the stride length, especially in men.

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The technique remains a significant performance factor, reflecting the biomechanical expediency of motor actions according to the purpose and state of the external and internal environment of the athlete's organism (6). This is because, as experts note, the technique changes significantly with the movement speed and under the influence of fatigue in the race's late stages (7-11).

Due to the very mechanics of walking and the inability to fold the knee joint when walking, the effectiveness is greatly influenced by the movement of center of mass (CM), which ~~as we know~~ must be carried forward with minimal deviations in the vertical direction. These deviations in elite competitors are within 50 mm. Some authors even believe the pelvis's specific movement would help lower these deviations and improve efficiency. Due to the inclination of the pelvis, the thigh is in the highest position above the center of the support leg (mid-stance) and the lowest, in the same position at the swing leg. This determines the s-shaped curve of the spine (rear-view in the frontal plane) (3), this shape-changing depending on which leg the support is on. From the point of view of all these opinions, a better understanding of the movement of the pelvis, and hence of its counterbalance – the arms and shoulder girdle would be beneficial for race walking (12).

From our available specialized sources, it is clear that the number of studies related to the muscle activity of the upper limbs needs to be more significant. At the same time, we will note that revealing their activity would help determine their contribution to improving the technique's effectiveness in race walking.

This examination follows the purpose of this study mining the muscle activity of selected muscles in the upper part of the body during race walking.

From this goal stem the tasks of the study:
1. Measurement of muscle activity of muscles on the upper body and carcass during race walking;
2. Definition of basic guidelines for conditioning work.

METHODS

We used a standard for this type of research methodology, which is surface electromyography. We were performed by an apparatus kit of BTS Bioengineering (BTS Bioengineering s.p.a., Italy), model FREEMG 300 (BTS bioengineering, Garbagnate Milanese, Milan, Italy) with a recording frequency of 1 kHz, sensitivity of 1μv and accuracy of up to 2%.

Muscle activity was measured during five double walking gaits, and the data obtained were processed by RMS (root mean square) with a time window of 300ms. The obtained data for the averaged values for the maximum and average muscle activity are presented in **Tables 1 and 2**. The following eight muscle groups were selected based on previous studies (13, 14). We used exactly these muscles because of their importance in walking: m. Erector spinae longissimus; m. Rectus abdominis; m. Obliquus externus abdominis; m. Musculus trapezius (middle part); m. Pectoralis major; m. Lattissimus dorsi; m. Deltoideus anterior & m. Deltoideus posterior) front and back heads.

Two experienced competitors in race walking (180 cm; 69 kg and 180 cm; 75 kg) were studied.

RESULTS

The measured muscle activity, its averaged mean, and the maximum value of muscles on the upper body is presented in **Tables 1 and 2.**

***Table 1**. Muscle activity (MA) of selected upper body muscles in race walking – athlete 1*

Muscle ⇨ State ⇩	L.[1] Rectus abdominis	L. Obliquus externus abdominis	L. Erector spinae longissimus	L. Latissimus Dorsi	R.[2] Trapezius transversalis	R. Deltoideus posterior	R. Deltoideus anterior	R. Pectoralis Major
Rest	0,016	0,007	0,010	0,011	0,008	0,014	0,008	0,011
Mean MA race walking (mV)	0,753	0,325	0,305	0,359	0,173	0,756	0,324	0,178
Peak MA race walking (mV)	1,077	0,426	0,397	0,475	0,302	1,157	0,324	0,265
Difference (%)	43,0	31,1	30,2	32,3	74,6	53,0	0	48,9

[1] L – left, [1] R- right

Some differences emerge between the data of **Table 1 and Table 2** regarding the absolute values of muscle activity of the selected muscles. The higher activity rates in competitor 1 compared to competitor two are impressive. This shows that competitors have different technical skills and different styles of execution. It would therefore be more accurate to use the relative activation values of the selected muscles demonstrated on the same tables.

***Table 2**. Muscle activity of selected upper body muscles in race walking – athlete 2*

Muscle ⇨ State ⇩	L. Rectus abdominis	L. Obliquus externus abdominis	L. Erector spinae longissimus	L. Latissimus Dorsi	R. Trapezius transversalis	R. Deltoideus posterior	R. Deltoideus anterior	R. Pectoralis Major
Rest	0,011	0,008	0,023	0,011	0,007	0,007	0,006	0,011
Mean MA race walking (mV)	0,178	0,058	0,147	0,209	0,078	0,194	0,019	0,014
Peak MA race walking (mV)	0,217	0,089	0,206	0,348	0,122	0,277	0,024	0,018
Difference (%)	21,91	53,45	40,14	66,51	56,41	42,78	26,32	28,57

From the relative activity of the selected muscles, already more equalized values on this indicator are noticeable **(Table 3).** The tendency for the highest activation for the persons studied to exhibit muscles is outlined. Trapezius transversalis (65,49%) m. Latissimus dorsi (49.41%) and m. Deltoideus posterior (47.91%) operates extremely actively in the dynamic mode of operation. The lowest activation has m. Deltoideus anterior (6.58%) operates instead in the isometric mode of operation.

***Table 3.** Average activity of selected upper body muscles in race walking competitors*

Muscle ⇨ State ⇩	L. Rectus abdominis	L Obliquus externus abdominis	L Erector spinae longissimus	L Latissimus Dorsi	R Trapezius transversalis	R Deltoideus posterior	R Deltoideus anterior	R Pectoralis Major
Difference between Average MA & Average PMA (%)	32,47	42,26	35,15	49,41	65,49	47,91	13,16	38,72

DISCUSSION

According to data from (15), the spine has the largest share in keeping the body steadily upright, particularly m. Erector spinae. It resists the strong diversion of the pelvis and the spine to the side of the swing leg. In the first case, the muscle is shortened on the side of the swing leg, and in the second – on the side of the supporting leg.

At the same time, the literature has a widespread thesis that the muscles in the carcass during walking perform a supporting role and work mainly in an isometric mode of operation. From the data obtained on the average and maximum relative muscle activity, we can partially confirm such an opinion of specialists, and only for m.Obliquus externus abdominis and m. Erector spinae longissimus. At the same time, the function of the hands as a passive means of controlling body rotation in walking and running has been proven (16). From the sources studied, the significant role of muscles is noticeable— Transversus abdominis (not investigated in the present study), m. Obliquus externus abdominis and m. Erector spinae longissimus to maintain the body's dynamic balance in sports movements. These judgments are confirmed by the slight difference between the relative mean and maximum muscle activity of the individual muscle groups, shown in **Table 3.**

The exception is m. Latissimus dorsi, whose primary function is motor, and in the case of race walking, since there is no rotation and abduction of the shoulder, its activity is surprisingly high. The lower muscle activity per m. Pectoralis major and m. Deltoideus anterior should not surprise us, as these muscles work together to perform specific movements other than those of walking. This suggests that the movement of the arms forward in front of the body in race walking is of a specific passive nature, which opinion has been confirmed by other studies (14).

Not surprising is the high activity of m. Trapezius transversalis, whose main function is to retract the blade (15, 17). In the case of race walking, its main function is in the backward and inward movement of the scapula and stabilizing around the vertical moment (12). The role of m. Transversus abdominis in maintaining the position of the carcass has been clear and confirmed by numerous studies (18). In contrast, the role of superficial muscles of the trunk needs to be more specific and explored in the scientific literature and even less so in race walking. There is a perception among the authors that it even changes depending on the movement speed. It has certainly been clarified that their peak activity is around the moment of initial contact (19). The primary function of m. External obliques and the m. Internal oblique is the folding and rotation of the trunk as their activity is similar while walking. Because of their function, it is noticeable that their peak value is observed in the transition from support on the left to the right side when the carcass is rotated (5); m. Erector spinae longissimus, in turn, works eccentrically, regardless of the movement speed, its main function being to hold the upright position of the spine. Depending on which leg the contact is, one side or the other is more active (13, 19).

From the table, the rather high muscle activity per muscles is noticeable. Rectus abdominis has as its main function the stabilization of the front wall of the trunk, but in certain cases, it may also have a motor one. Here comes the essential difference between walking and race walking in the work of this muscle, which is much more active during race walking ~~and normal walking~~ (12, 13, 20). This is likely due to the pelvis sagging and the arms' active work.

In conclusion of the literature review, we can argue that, in general, m. Quadriceps femoris has an important stabilizing role in the amortization phase in order to keep the knee unfolded during the same. Thus together with the m. Biceps femoris stabilizes the leg during support. In turn, at the same time, m. Gastrocnemius and m. Tibialis anterior control the rotation of individual parts of the foot, indirectly helping to unfold the knee. Another important role of these muscles is the execution of propulsion.

The authors' studies show that these muscles are activated to one degree or another, more or less depending on the movement speed and the level of the competitors (8, 10, 11). The main difference is observed during the moment of initial contact with the support when the muscles exhibit higher activity caused by the higher speed. Another difference is that the muscles m. Tensor fasciae late and m. Quadriceps femoris need faster switching from operating to relatively passive operation. At the same time, with an increase in the movement speed, the muscles along the trunk and the proximal part of the leg exhibit greater activity (19). Hence, the lack of muscle strength of the torso muscles, which helps maintain good posture and balance, especially during movement, can lead to technical errors, expressed in incorrect knee movement and a visible lack of contact with the support.

From all of the above, in the preparation of athletes in race walking, considerable attention should be paid to certain muscles and muscle groups that are the basis of movement. From the kinematic analysis, it became clear the great importance of the ankle joints in race walking, whose movements are governed mainly by the musculature of the lower leg. This makes them the main goal of conditioning in race walking. From their position, at the moment of initial contact of the foot to the support, the muscles tied to one degree or another with the knee joint (muscles and muscle groups on the thigh) experience the most significant load, determining the need for their additional strengthening. Another direction of work for conditioning training is the muscles in the trunk because of its twisting movement. Here it is essential to pay attention to m. Erectro spinae and m. Rectus abdominis. Of the muscles on the upper limb with the most significant role in sports, walking is distinguished m. Deltoideus posterior. The economy of movements is related to the muscular coordination of synergists on the one hand and antagonists on the other. Muscles should work in sync without unnecessary tension. This is helped by the unfolded position of the leg, which reduces muscle tension along the front of the lower leg while storing the potential energy needed during the amortization and contact with the support. The knowledge of the muscular activity of the working muscles will help improve the technical performance and hence the economy of movements.

CONCLUSIONS

From the studies and the results obtained, the following conclusions are required:

1. Based on the technical skills of the competitors, some differences in muscle activity are differentiated, which will inevitably lead to different biomechanical expediency of the movements;

2. The results suggest that the main work should be directed toward the muscle of the back of the trunk, namely m. Trapezius transversalis, m. Latissimus dorsi and m. Deltoideus posterior.

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