Bulletin of "Carol I" National Defence University
10.12753/2284-9378-20-09

WALKING – ANATOMICAL AND FUNCTIONAL ASPECTS AND ITS ROLE WITHIN MILITARY PHYSICAL EDUCATION AND THE MILITARY ENVIRONMENT

Lt.Col.Lect. Gabriel Constantin CIAPA, PhD*

Whether we regard walking as an ordinary automatism of the people to whom we do not pay any particular attention, or we look at it from the perspective of specific basic motor skills and the actions and activities of the servicemen, it must be admitted that it is the main form of human locomotion, the main mode of human movement. Beyond the applicative utility of walking, in a deep approach, it must be understood as the central component of movement, a quintessence of the existence of human life on Earth, along with the other elements that support our survival: oxygen, water and food. This material comprises a synthesis of the main information that will help get a deeper understanding of walking and an awareness of its role both for daily life and as a fundamental motor skill needed for the servicemen.

Keywords: walking; movement; physical activity; marching; running.

According to Charles Darwin's evolutionary theory, animal and plant species undergo transformations as a result of their ability to adapt to environmental conditions, of the overpopulation in different geographical areas, of the need for survival and the struggle for existence, of their genetic traits but also following the imprint that nature leaves on them. Man, according to the same theory, is no exception, being subjected to essential changes that clearly delimit it from animals.

Throughout history, our ancestors made the transition from four-legged walking to bipedal walking, evolving from the instinctual-animal actions to rational actions using articulated language. Bipedalism is a fundamental characteristic of man, a key element for human movement, a factor whose lack would question our existence in the current form. The transition to bipedalism determined changes in the entire osteo-articular and muscular apparatus, changes that produced adaptations, firstly in the lower limb muscle groups in order to increase the strength developed by them due to the need to support body weight. Also, the degree of freedom for performing movements in the joints of the lower limbs also supports adaptations and modifications required by human evolution.

**"Ferdinand I" Military Technical Academy*
e-mail: *gabriel.ciapa@mta.ro*

Walking – anatomical and functional issues

In order to create a correct overview of walking, conceptually speaking, it is necessary to treat it considering two directions of analysis that are conditioned and interlock each other: the first consists in its approach taking into account the anatomical – biomechanical component, and then the awareness of the importance of the body's correct movement is the essential objective of this definition; the second perspective aims at treating walking from the point of view of physical education and of the applicability for the preparation of servicemen, the final conclusion being drawn towards understanding its usefulness in the military field.

But what is walking? In the anatomical-biomechanical sense, walking represents a cyclical locomotor movement of the lower limbs, by bringing one foot in front of the other and which, initially, is a voluntary motor action and becomes, as a result of exercise and repetition, an automatism, an involuntary act.

Walking can also be seen as a succession of "permanent imbalances and rebalances, whereby the body adapts to the supporting surface and the environment, permanently maintaining contact with the surface on which the movement is performed (n.n. – this is one of the fundamental characteristics that distinguishes walking from running. There is a moment in running – the flight phase, in which any contact with the support surface disappears)"[1].

During walking, the lower limbs successively act as support and propulsion, determining the appearance of the functional elements of walking: support on a single lower limb, support on both lower limbs and the balance or advancement of a lower limb. When the weight of the entire body is supported by a single leg (supporting lower limb), during walking, we speak of unilateral support, when the other leg performs the balance-pendulum movement (its forward design as a result of muscle contraction) and bears the name of a pivoting or swinging leg. When the body's weight is supported by both feet, we speak of bilateral support. The moment when, during movement, the swinging leg reaches the support leg is called the moment of verticality.

In addition, walking consists of two different periods, during which the lower limbs perform the functions stated above. The two periods are: support and balance (pendulum, oscillation). During the support period, there are several moments: "initial contact (with the heel), loading, medial support (with the middle of the sole), termination of the support (loading towards the forefoot), detachment (from the ground)"[2].

These moments can be divided into two phases: the posterior phase of the unilateral support and the second, previous of the same support. Between these two phases the moment of verticality is also interposed. The second period, balance, consists of the "initial (posterior), medial or middle and final (terminal, anterior) oscillatory movements"[3]. These phases create the cycle of walking (Figure 1).

The fundamental elements specific to walking are: "the anti-gravitational support of the body - provided by the body's anti-gravitational reflexes; balance – consists in maintaining the balance and the direction of movement (n.n. – the position of the body's center of gravity, during the movements, it undergoes changes as a result of the weight transfer from one segment to the other); propulsion – occurs due to anterior and lateral tilt of the body, before support on a lower limb; stepping"[5].

Stepping, being an essential component of walking, has as a trigger element the need to contact the support surface and the inclination of the body when the body's mass passes from one foot to the other. It has the double step as basic functional unit which, according to Mary, represents the totality of movements that we perform between two identical positions of the body. The double step can also be defined as the movements made between two successive support positions of the same leg. A simplistic definition of the double step can be understood as a sum of two simple steps. The simple step is defined, according to Littre, as "the distance between the two heels, when the legs are supported on the ground"[6]. Tudor Sponge considers the step as "the distance between the contact point of one foot (left) and the contact point of the other foot (right)"[7].

Normal walking is characterized by a series of parameters, and their values particularize it for each individual. These parameters (Figure 2) are: the length of the step (the distance between the heel of the same lower limb, relative to two identical

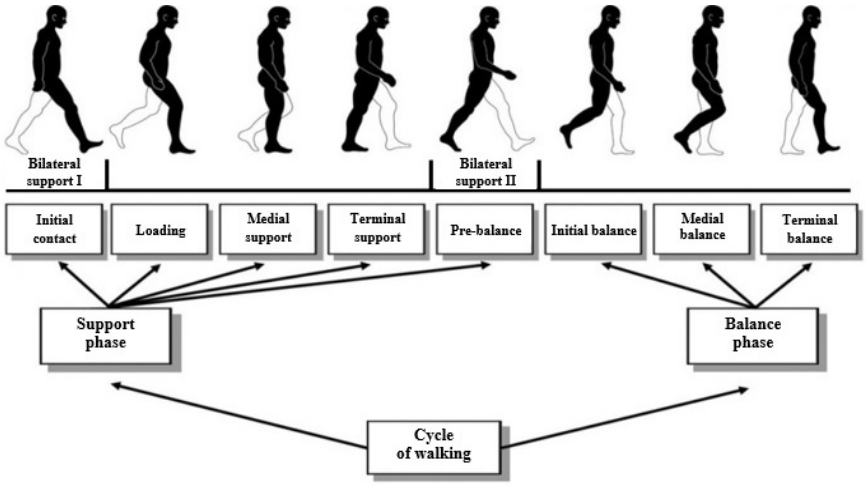

Figure 1 *Cycle of walking*[4]

positions of the body) – 70-80 cm, its width (the distance between the heel of the lower limb and the line of walking direction) – 5-6 cm, the angle of the step (is given by the longitudinal axis of the foot

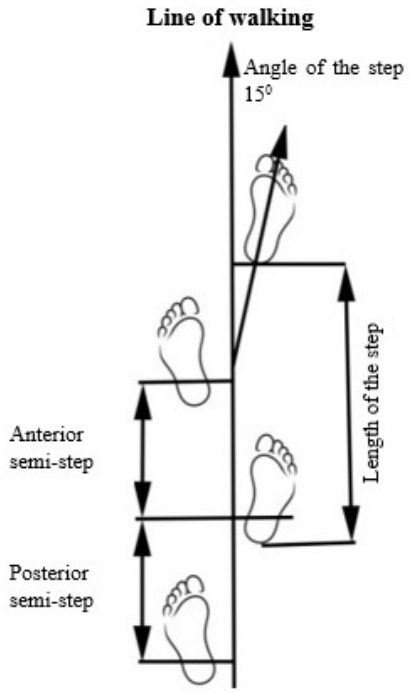

Figure 2 *Coordinates of walking*[8]

and the line of walking direction) –approx. 15°, the cadence or pace of walking (for a slow walk, the number of steps is about 60-80 steps/minute, for an average one – 80-100 steps/minute and for an alert walk we have values between 90-120 steps/minute), speed walking – 4-6 km/hour, the length of a walking cycle is between 150-160 cm.

Another extremely important indicator that I mention, given that people are looking for a way to move and reduce fat tissue, is the body's energy consumption during walking. During walking, a person with a weight of 75 kg, at a moderate speed of about 5 km/hour, consumes about 4.8 calories/minute, in total 288 calories/hour.

During walking, the human body is subjected to several types of oscillatory movements, which are of three types: vertical, transverse and longitudinal. The vertical oscillations are represented by the ups and downs of the body's center of gravity (it is arranged near the vertebrae of the second sacral and five cm before it, on the vertical axis of the body), with an average amplitude of this movement of about 4,5 cm. The maximum lifting moment is reached when the moment of verticality is achieved. The minimum threshold is reached at the time of bilateral support.

The second type of oscillations, the transverse ones, with an average amplitude of the movement of approximately 4.4 cm, having the maximum also at the moment of verticality, are found during the successive inclination of the trunk on the support leg, when the support phase is performed during movement.

The longitudinal oscillations are identified with the movements of the trunk in the sagittal (anteroposterior) plane, in the forward-backward direction. These movements can be observed in the moments of tilting the torso forward and backward, in the moments of unilateral anterior and posterior support of the lower limbs. All these three types of oscillations determine the movement of the center of gravity on a sinusoidal trajectory both vertically and horizontally.

The analysis of walking highlighted the existence of a number of 6 fundamental movements: "rotation, tilting and lateral displacement of the pelvis (n.n. hip), flexion of the knee, movement of the foot and knee"[9].Thus, the pelvis performs two rotations: one around the vertical axis of the body towards the lower limb that advances by about 4°, summing up a total of 8° and the second rotation, around an anteroposterior axis of about 4°-5°. Also, the pelvis moves in a horizontal plane, left-right, depending on the lower member performing the support phase.

But how is normal walking done correctly? From the upright position, with bilateral support (first), one of the lower limbs initiates the movement by advancing with the heel of the foot. In this position, the foot of the lower front limb is flexed on the calf at an angle of approximately 90° and 30° to the ground, the knee is almost fully extended, the lower limb is in anterior support and initiates the movement. In this phase, the arm opposite the advancing foot is slightly projected in front, the head and the trunk remain upright.

The following moment, the one-sided support (first), is achieved by the support of the front leg and the swing of the back leg. The lower limb in front takes on the entire body weight and rests its entire sole on the ground. The rear one makes a quick movement (a swing), from back to front.

The knee of the support leg is almost extended, the arms are close to the body, the trunk and head are upright. When the lower back member reaches the lower support member, that moment of verticality is created, as I mentioned earlier.

After this, the lower support limb continues the body's propulsion. The lower limb pendulum continues its forward movement and sits on the ground with the heel, at which point we have the second position of bilateral support. During the movement, the knee and ankle of the lower limb are slightly flexed, the pelvis also performs a forward rotation, the opposite arm is also slightly forward, the trunk and head are upright.

The following phase is balance, in which the swinging lower limb becomes supportive and the other will play the role of the swinging foot. The latter will perform the detachment from the ground, swinging it forward, reaching the moment of the vertical and preparing for its placement with the heel on the support surface, preparing the next cycle of walking. Throughout this stage the head and the trunk maintain their verticality, the opposite upper limb will move forward simultaneously with the design of the swinging leg in front.

Moreover, the amplitude of movement of the upper limbs for the two phases of walking is variable, being conditioned by the speed of walking and, in some cases, by the length of the step. The trunk and upper limbs play a role in maintaining the body's balance throughout walking.

A distinct element of walking is the way of placing the foot on the ground, and this mode is called the pronation of the foot. As it is known, each of us places the foot differently on the support surface and we have different shapes of the sole. "This shape of the sole can be normal, with a high or flat arch – platfus. From the point of view of the pronation, we can place the foot more on its external side (insufficient or lateral pronation), normally or more on the internal part of the foot (exaggerated or over pronated pronation). For each of these, it is recommended that the shape of the sports shoe be as follows: semi-curved for a normal pronation, curved for a lateral pronation or straight for the exaggerated pronation"[10].

Going further with our analysis, we can talk about walking from the standpoint of physical education and its applicability to the military environment. Walking is a motor action[11] and it is a component of human motor skills[12], performed consciously in most situations and which, apparently, is quite easy to achieve, automatically, based on segmental coordination, when attention is obviously directed towards the direction of walking.

The place of walking within military physical education and the military environment

The normal walking technique can be modified or even disturbed by the voluntary or involuntary occurrence of internal or external triggering factors. These internal (for example, the degeneration of the joints of the lower limbs or mental processes such as will) or external (the appearance of obstacles in the direction of walking) factors can lead to the appearance of specific variants of walking.

If in military physical education, walking with its variants (walking on tip-toes, walking on heels, walking on the outside parts of the soles or on the inside, crouched walking, with added steps, with crossed steps, with a knee lift, in lunges, etc.) is most often found in the form of preparatory exercises, in the military environment, walking has strong applicative connotations. In the military environment we find it in two situations: the first, in the training and education activity, and the second is the movement of troops on foot (march), of tactical and combat situations.

From the point of view of the teaching and training activities, walking with its variants is found at the beginning of the lessons in the form of exercises for warming up the lower limbs and their joints. Regarding the second situation, walking is the essential motor activity for the movement of troops on foot, of march. Moreover, the march represents "the movement of a subunit/military unit (of the troops and of the equipment provided), mainly on foot, with limited access to the support of vehicles ... A march is considered to be a successful if the troops reach their destination at the set time and are physically capable to carry out their mission"[13].

As far as walking and the combat situations are concerned, the table below shows some moments in which we find it, of course, next to other motor skills useful in applications.

Table no. 1

WALKING IN DIFFERENT COMBAT SITUATIONS[14]

SHOOTING	PHYSICAL REQUIREMENTS
Throwing hand grenades	Walking, running and carrying cargo, jumping, crawling, climbing, pushing, pulling, squatting, lunges, starting, stopping, changing direction, throwing.
Movement	Physical requirements
Individual movement techniques	Walking, crouching, running and transport of cargo, jumping, crawling, climbing, pushing, pulling, squatting, lunges, starting, stopping, changing direction, climbing and descending.
Movement from one point to another	Walking, crouching, running and transport of cargo, jumping, crawling, climbing, pushing, pulling, squatting, lunges, starting, stopping, changing direction, climbing and descending.
Movement under enemy fire	The motor skills mentioned above (walking, crouching, running and transport of cargo, jumping, crawling, climbing, pushing, pulling, squatting, lunges, starting, stopping, changing direction, climbing and descending) executed at high speed and with precision.
Survival	Physical requirements
Close combat	Reactions in close combat: pushing, pulling, pacing, walking, running, racing, throwing, lifting body weight, squatting, lunges, rotating, bending, locking, kicking, arm-banging, stopping, changing direction.
Adaptation to situations	Physical requirements
Threat assessment and response (force escalation)	Reactions to direct physical contact: pushing, pulling, running, racing, throwing, lifting body weight, squatting, melting, rotating, bending, locking, kicking, arm-banging, changing direction, weight-bearing, jumping, crawling, climbing, start, stop.
Fight abilities	Physical requirements
Reaction to direct contact with the enemy	Walking, crouching, running, pushing, pulling, racing, throwing, lifting body weight, squatting, lunges, rotating, bending, locking, kicking, arm-banging, changing direction, weight-bearing, jumping, crawling, climbing, start, stop.
Evacuate the wounded	Lunges, crouching, lifting weights, walking, running, transport.

Conclusions

Knowing the correct walking technique and applying it to real situations can turn this motor activity into a moment of relaxation, a recreational process. Following some basic rules during walking (keeping the head and torso in an upright, high position; directing the gaze forward at 10-15 m, not on tip-toes; allowing free movement of the upper limbs forward and backward from the shoulder joint; keeping the shoulders in a low and slightly backward position; keeping the pelvis in a neutral position; having a slight tension of the abdomen; light walking) will increase its efficiency, obtaining essential benefits for our state of health.

Adding the applicability of walking in the military field, where it is evident when troops must move and transport materials, to its sanogenetic effects (lowering blood pressure, reducing heart disease, risk of type 2 diabetes, depression, fat tissue, as well as memory enhancement), we can certainly admit that this is a good physical exercise for maintaining and developing the military capabilities of the servicemen, but also a pleasant and useful way to spend their leisure time.

NOTES:

1 M. Cordun, *Kinetologie medicală*, AXA Publishing House, Bucharest, 1999, p. 78.

2 T. Sbenghe, *Bazele teoretice și practice ale kinetoterapiei*, Medical Publishing House, Bucharest, 1999, p. 304.

3 *Ibidem*, p. 304.

4 Translation Tino Stöckel, Robert Jacksteit, Martin Behrens, Ralf Skripitz, Rainer Bader and Anett Mau-Moeller, *The mental representation of the human gait in young and older adults,* Frontiers in Psychology, 2015.

5 M. Cordun, *op.cit*., p. 79.

6 *Ibidem*, p. 79.

7 T. Sbenghe, *op.cit.*, p. 303.

8 M. Cordun, *op.cit.*, p. 79.

9 T. Sbenghe, *op.cit.*, p. 304.

10 G.C. Ciapa, *Orientări și oportunități pentru pregătirea fizică a militarilor*, "Carol I" National Defence University Publishing House, Bucharest, 2019

11 The motor actions represent a "sum" of motor acts (these are the simplest gestures of human movement, realized with the help of the skeletal musculature and the bone system through which rapid adaptations to the situations encountered are realized or the motor actions are created) with the purpose of reaching to an immediate goal.

12 A. Dragnea et al., *Educaţie fizică şi sport – teorie şi didactică*, FEST Publishing House, Bucharest, 2006, p. 3: "The processes and mechanisms by which the human body or its segments move, detaching itself from a landmark, through muscular contractions".

13 G. F. Băițan, *Pregătirea fizică a militarilor din Armata României în contextul întegrării în NATO*, "Carol I" National Defence University Publishing House, Bucharest, 2019, p. 144.

14 Adaptation after*FM 7-22: Army Physical Readiness Training*, Headquarters, Department of the Army, Washington DC, 2013, pp. 1-4.

REFERENCES

[Department of the Army], *FM 7-22: Army Physical Readiness Training*, Headquarters, Washington DC, 2013.

[Department of the Army], Field Manual No. 21-18H FM 21-18, *Foot Marches,* Headquarters, Washington DC, 1990.

[Headquarters Department of the Army Washington DC], ATP 3-21.18 (FM21-18), "Foot Marches", *Army Techniques Publication* No. 3-1.18, 17 April 2017.

Băițan G.F., *Pregătirea fizică a militarilor din Armata României în contextul integrării în NATO*, "Carol I" National Defence University Publishing House, Bucharest, 2019.

Ciapa G.C., *Orientări și oportunități pentru pregătirea fizică a militarilor*, "Carol I" National Defence University Publishing House, Bucharest, 2019.

Ciapa G.C., *Pregătirea fizică a militarilor din armata României în conflictele moderne*, "Carol I" National Defence University Publishing House, Bucharest, 2018.

Cordun M., *Kinetologie medicală*, AXA Publishing House, Bucharest, 1999.

Dragnea A. şi colab., *Educaţie fizică şi sport – teorie şi didactică*, FEST Publishing House, Bucharest, 2006.

Sbenghe T., *Bazele teoretice și practice ale kinetoterapiei*, Medical Publishing House, Bucharest, 1999.

Stöckel Tino, Jacksteit Robert, Behrens Martin, Skripitz Ralf, Bader Rainer, Mau-Moeller Anett, *The mental representation of the human gait in young and older adults,* Frontiers in Psychology, 2015.

https://www.health.harvard.edu