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OVERTRUSE SYNDROME IN THE RUNNING

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SUMMARY

Walking and running are natural way of human motion. Today running is effective aerobic exercise to maintain vital human functions, mostly cardiovascular and breathing functions. Modern human's lack of movement results in numerous health problems and generally reduce the quality of his life. The impact of regular physical exercise on the body is proven beyond any doubt; but we can also see the growing negative effects of physical exercise, which are typically a result of the unadjusted and to demanding exercise programs. Walking and running are human's the most effective and health activities, but running can have large load on joints, bones, tendons, ligaments and muscular system. The negative effects of physical exercise are manifested in the form of overuse which often leads to injuries. Running injuries and their development takes place at the beginning relatively unnoticed, obvious symptoms with pronounce consequences for the runner occur relatively late. Identifying overuse factors of the human can help runners and all other athletes who run in their sport disciplines; it is a huge challenge for sports science. Correct and in time answers on overload can have important contribution to a more humane and safe practice.

Key Words: running, biomechanics, overuse syndrom.

INTRODUCTION

Running is besides walking the most natural man movement; which he used in his evolutionary development on a daily basis to survive. Today running is basic content of aerobic exercise, one of the most effective ways of maintaining functional systems, in particular cardiac vascular and respiratory system. Modern way of life, when people are working longer and longer, more and more tiring and stressful, more time spent in a sitting position, running can be the best counterweight to such a lifestyle. Quality of life of the modern "Homo sitter", the lack of movement decreased markedly with all the consequences that are evident in many diseases of our time. Nothing destroys the human body more than the non-movement (Aristotle).

Running as a physical activity is genetically determined. The basic running structural unit is double step. Within the cycle running cycle alternates support and flight phase. Support phase begins at the moment when the foot strikes the surface and ends when the foot leaves the ground. Moment of leaving foot from support delimits both phases. When foot touches the ground with heel is the first support, and when the take off is done with finger is called last support. Between a supporting phase is the flight phase. The distance between the two phases defines the stride length. In addition to the frequency step is the most important step length parameter of running. Step length and step frequency are in inverse proportion and are individually conditioned. They depend on runner's characteristics and capabilities. At higher frequency is smaller stride length and vice versa. Parameter stride length depends on the morphological characteristics of runners, especially the length of the lower extremities, from the ground reaction force, contact time and take off angle. The average stride length of the recreational runner is 100 to 150 cm, a top runner 150 to 220 cm. Frequency step, which is manifested by the number of steps per unit time depends on the intra and inter muscular coordination and operation of the central nervous system that regulates the movement of agonist and antagonistic

muscle groups (Donatti, 1995; Komi & Nicol, 2000; Mero, Komi, & Gregory, 1992; Novacheck, 1997). The relationship between length and step frequency steps is largely automated and fixed in locomotor central nervous system (Enoka, 2003). Human running technique is very individual and independent with stage of training.

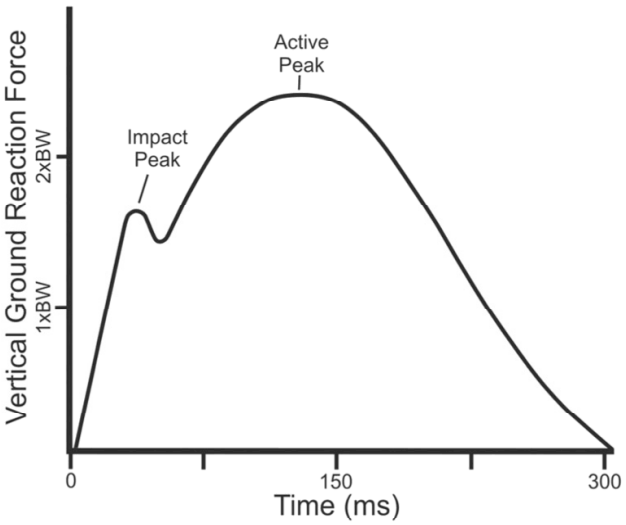
BIOMECHANICS OF RUNNING

Maximum load on human body is created the first and last support phase (Figure 1), vertical reaction force is between 2000 to 2500 N, during sprint even up to 3500 N (Cavagna, Komarek, & Mazzoleni, 1971; Mero et al., 1992, Škof & Strojnik, 2007). Gait reaction forces are three times smaller (Novacheck, 1997). The main difference between walking and running is flight phase, which do not exist in walking. During walking the human body is always in contact with one foot on the ground.

The foot is one of the most loaded segments of the locomotor system during running. The foot has 26 bones of different shapes and features, 19 muscles and more than 100 ligaments. In the course of 10 km,

FIGURE 1

Vertical ground reaction force in the touch-down and take-off phases (Source: Foot strike in runners: Influence on injury risk, 2012).



the foot strikes the ground about 5.000 times, the average stride length of 2 m. With average runner's mass (70 kg) and regarding to the number of steps, we can conclude that the total absorption reaction of surface forces for each foot is 3430 kN. This force is then transmitted to the knee and hip joint. Undoubtedly, these burdens are on the borderline of human adaptive capacities.

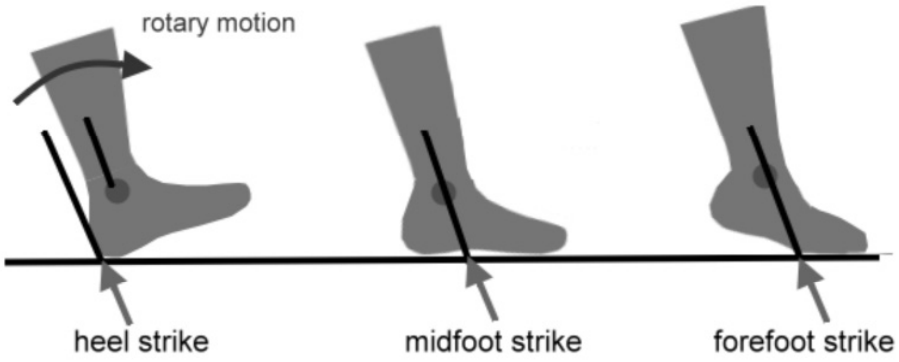
Runner's reaction force depends on the running technique, how foot is placed on ground in the moment of the first contact. We differentiate three types (Daoud et al., 2012; Hasegawa, Takeshi, & Kramer, 2007; Lieberman et al., 2009; Novacheck, 1997): with heel (RFS rear-heel foot strike), mid foot (MFS mid--foot strike) and fingers (FFS fore foot strike) – Figure 2. Hasegawa et al. (2007) found that 75% of marathon runners use RFS, 24% MFS and only 4% FFS. Which of the run models are the most effective researches up to date did not give a single answer (Lieberman et al., 2009). Superior results were achieved during the marathon runners with all three types.

Placing foot is closely related to the function of modern running shoes, which are constructed according to the latest knowledge of biomechanics and functional anatomy of the foot. The basic task of running shoes is the mechanical protection of the feet, partial neutralization of reaction forces and injury prevention. Rear – foot strike means in terms of burden "shock" to the ankle, knee and hip joint. Reaction force in this case is oriented in the opposite direction of motion of body center of gravity. In part, this force is absorbed by running shoes sole, which must be appropriately thick and elastic.

In terms of biomechanics of running a more efficient technique is to place foot in the first contact to the front outside part (Figure 3). In this mode, the foot like a spring partially neutralizes the reaction force. Contact with the front foot, however, requires proper coordination and activation of agonist and antagonist muscles (m. tibialis and m. gastrocnemius medialis and lateralis). M. Gastrocnemius muscle provides necessary preactivation needed for proper

foot stiffness (Komi & Nicol, 2000). When are muscles activated 50 milliseconds before touchdown, less energy is lost than a passive setting foot on the heel. Efficiency and economy of running is not only dependent on the production of chemical energy, but also on the amount of mechanical - elastic energy that is generated in the eccentric phase (the first phase of foot contact with the ground). Economic running technique is combination of efficiency of chemical and elastic energy. According to researches (Enoka, 2003; Komi & Nicol, 2002; Mero et al., 1992) the proportion of chemical energy and, elastic energy is 75 : 25%.

FIGURE 2
The foot plant techniques in running
(Source: Foot strike and injury rates, 2012).



During evolution walk and run have helped man to survive in raw nature. The man ran and walked barefoot for about four million years. Only in the modern era has started using shoes. Running shoes are little more than sixty years old, which is in context of the history of time. Running shoes have changed the technique of running. Barefoot man ran through the front foot and by exploiting the elasticity of muscles, tendons and ligaments (Lieberman et al., 2009). Today's modern runner sets foot on the heel and exploits the elasticity of the lower part of running shoes. The basic functions of running shoes are absorption of impact forces at the feet with ground, stabilization of ankle and foot and provide a good grip (friction). It is important that the front part of the sole is rigid enough, which prevents excessive foot supination and plantar fascitis development.

OVERUSE SYNDROM

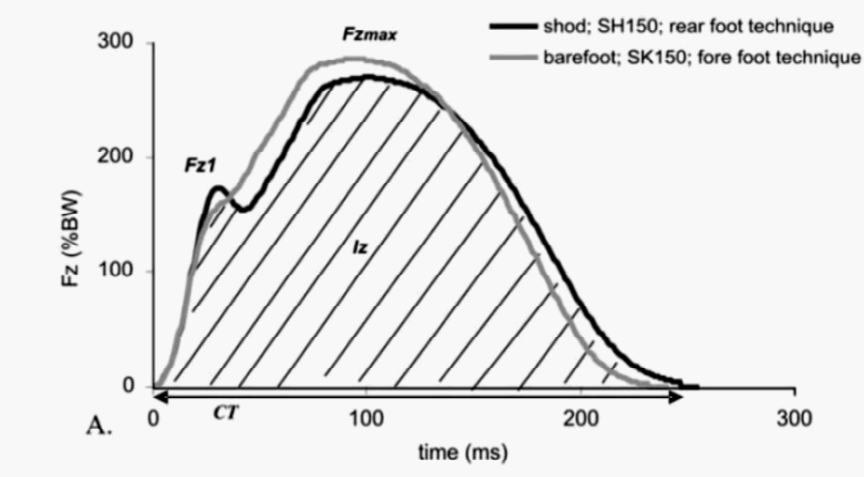
Despite the fact that running is one of the most effective and healthy human motor activity, it can also have high impact on locomotor system, especially for joints, tendons, ligaments and muscle system of lower extremities (DeRuisseau et al., 2004; Halson & Jeukendrup, 2004; Hartmann & Mester, 2000; Mujika, 2009). The negative effects of sports training show as "collateral damage" in the form of various injuries. The first type of injury is acute one that occurs immediately with the known mechanism of injury and place. The second type chronic injuries are primarily due to overuse of the motor system, in particular segment of the lower extremities. Chronic injury is taking place in the beginning usually completely unnoticed, obvious symptoms with noted consequences for the runner occurs relatively late. First signs of chronic injuries are attributed to bad warm up, excessive load, unfavorable external influences; runner continues with sports activity, problems are not heavy and there is no sign of injury (Urhausen & Kindermann, 2002). To the difficulties which are associated with overuse syndrome runners react late or too late. On muscle, tendon, ligament, cartilage, bone, nerve and blood vessel is continuous load which can cause micro-trauma and micro-stress. The most common external causes of overuse syndrome are: improper motor preparation, running technique, rapid changes in the intensity of training, inadequate configuration of the terrain, frequent one-sided load, inadequate rest and recovery, inadequate climatic conditions and inadequate equipment. The internal causes of overuse syndrome may be genetic or acquired. In general the morphologic characteristics of the body manifest different level of asymmetry. The reason may be also the biochemical change in the organism. Important role play age and gender as well. It is important to identify and analyze causes and act accordingly. The entire process of eliminating both external and internal causes of overusing the motor system requires a team approach with work-oriented

specialists. These are coaches, physiotherapists, masseurs, doctors, orthopedic surgeons. Kinesiology profession and science can play a key role in early identification and prevention of the occurrence of overuse syndrome. This applies to all those athletes, who use running in their sport (weather monostructur or polystructur).

With load increase body adapts to stress with muscle fibers hypertrophy, with collagen tendons and ligaments reinforcing structure and bone tissue density increase. Overusing can instead adapt to stress in the athlete's body causes various pathological responses, which result in metabolic disturbances, inadequate supply tissues with oxygen and aseptic inflammation (Hartmann & Mester, 2000). Survey (Auersperger, Ulaga, & Škof, 2009; Auersperger, et al., 2012) showed that the eight week endurance exercise had negative effect on iron balance in women. Hepcidin was significantly lower after three weeks and after the end of the survey. After the end of the study two-thirds of subjects had reduced iron reserves. At a certain stage overuse syndrome is reversible with appropriate therapeutic and regenerative processes. However, when this threshold is exceeded appears tissue metaplasia. At muscle insertion and muscle tissues appear scar tissue, calcium reserves, insertion ossification in tendons ossification and muscle ossification. The entire process takes six to eight weeks. Results show in deterioration of the muscle-tendon structures, cartilage and bones, which are no longer able to fully carry the load. Musculoskeletal system responds with pain and swelling, damaged muscles, ligaments, tendons

FIGURE 3

The differences in the development of the ground reaction force – the rearfoot and fore-foot techniques (Source: Divert et al., 2008).



and bone stress fractures. Most are affected muscles insertions, some tendons (most often Achilles tendon) and fascia. A common feature overuse syndrome is indicated with pain and impaired function of the locomotor system (Zatsiorsky & Kraemer, 2006).

Achilles tendon is undoubtedly the most critical part in runners. Painful Achilles tendon may remove athlete from training for several months. Achilles tendon is a thick fibrous bundle which connects muscle gastocnemius lateralis and medialis, and soleus with heel. Tendinopathy is one of the most common injuries in runners. Tendinopathy means painful and swollen Achilles tendon accompanied by reduced functionality, which can cause tendinitis (inflammation) or paratenonitis (inflammation of the fascia). Tendinopathy occurs approximately 2-6 cm above tendon insertion. Tendon pain occurs due to the high forces and long-lasting load. With tendinopathy microscopic tears occur in tendon and fascia. On tendon scar tissue begins to accumulate. The basic function of the Achilles tendon is the transmission of force generated by muscle to bone, besides it also works as schock-absorber against external forces and prevents muscle's damage. This feature requires appropriate elasticity, flexibility and tensile strength. Achilles tendon load in sprint can reaches 9 kN and 2.6 kN with slow running (Lieberman et al., 2009; Urhausen & Kindermann, 2002). At peak forces tendon can partly or totally breaks. Tendon partly can break up the first degree (when are interrupted 5% to 50% fibers) and the second degree (when are interrupted 50% to 80% fibers). Point of complete rupture occurs when tendon extends 10% to 20% of initial length.

CONCLUSION

Running is an integral part of many competitive sports. Walking and running are natural forms of exercise, one of the most appropriate ways of maintaining good physical fitness and wellness. There is ample evidence that walking and running reduces stress, lowers blood pressure and total blood cholesterol levels. These are all important reasons for the popularity of walking and running as a regular form of recreation, which in recent years continually growing. Nevertheless running have indisputably proven positive impact on human, in recreational and competitive sport we have noticed growing negative effects of wrong sport training, which usually results from unadjusted and to demanding exercise programs. Many injuries are also associated with different running content. Running can have also high load, especially for joints, ligaments, tendons and muscles of the lower extremities. As a result of excessive load number of injuries of the locomotor system can be seen: running knee, Achilles tendon tendinitis, iliotibial syndrome, plantar fascitis, ankle sprain and other physiological--biochemical changes in the organism.

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