DOWNLOAD PDF MECHANICAL AND PHYSIOLOGICAL DIFFERENCES BETWEEN RUNNING AND WALKING AT VARIOUS VELOCITIES

Chapter 1 : What Is the Difference Between Walking & Running Strides? | racedaydvl.com

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A general consensus is that FR is faster than BR. The results from this study confirm that widespread belief. Overall, BRmax velocity was The individual range for BR to FR was Like several BR variables, the maximum length of a BR stride was unknown. Since the product of stride length and stride frequency equals velocity, and since it was assumed velocity would be lower in BR than FR, it was hypothesized that stride length would be greater in FR. The results of this study confirmed this hypothesis. It was also hypothesized that stride frequency would not differ between BR and FR and that individuals have a motor program set of directions in the brain for stride frequency independent of running direction. For example, during BR extension prior to ground contact, the hip joint is constrained by the anterior musculo-tendinous units spanning the hip joint. Also, the knee may be constrained in extension at or near toe-off. BR also requires muscular work from the hamstring muscle group to slow the knee prior to full extension to prevent hyperextension and injury. Knee joint proprioceptors sense joint extension and send neurological signals to activate antagonistic muscles to avoid damage to the knee joint structure. This antagonistic muscular force is counterproductive to BR velocity. As the runner moves backward, the ankle angle increases as opposed to decreasing as in FR, lessening the amount of plantar flexion available and thus limiting propulsive potential since the dorsiflexors are not capable of producing as much torque as the plantar flexors. A shorter hip to toe distance at ground contact could mean less braking force. The comparison of hip to toe distances at toe-off showed no condition differences, suggesting that this variable might be related more to velocity than direction and supporting the idea of a "longer hip to toe distance at toe-off-- greater velocity" relationship. Since a runner can only produce force while his foot is in contact with the ground, it is logically assumed that a greater velocity can be generated from a longer hip to toe distance at toe-off. Nilsson, Thorstensson, and Halbertsma research supported this concept when they found that the distance from the center of gravity to the toe increased as velocity increased. Analysis of ground reaction forces could add valuable information on the differences and similarities between high speed BR and FR with respect to differences in ISL. The velocities in this study averaged nearly 2 m s-1 greater than Threlkeld et al. For athletes wanting to increase their BR velocity, it appears that stride length, not stride frequency is the factor in the velocity equation that needs to be addressed since stride frequency is already significantly greater for BR than FR. The human has greater anatomical constraints with respect to the hip, knee and ankle in BR than FR. It is unknown what BR stride length can be obtained with training. A kinetic analysis of these three conditions may provide further guidance to individuals and coaches wanting to improve BR velocity. Future kinematic studies should investigate the differences between elite and non-elite backward runners at percentages of maximum BR velocities. A comparison between forward and backward running. The Olympic Scientific Congress Proceedings: Lower extremity joint kinetics and energetics during backward running. Medicine and Science in Sport and Exercise, 23, Patellofemoral joint compressive forces in forward and backward running. Comparison of cardiopulmonary responses to forward and backward walking and running. Medicine and Science in Sport and Exercise, 26, Mechanical power and muscle action during forward and backward running. British Journal of Sports Medicine, 15, Changes in leg movements and muscle activity with speed of locomotion and mode of progression in humans. Acta Physiological Scandia, , Kinematics, ground reaction force and muscle balance produced by backward running. A kinematic comparison of backward and forward walking in humans. Journal of Human Movement Studies, 13, Backward walking a simple reversal of forward walking? Journal of Motor Behavior, 21,

Chapter 2 : Walking vs. Running: Which One Is Best? / Fitness

MECHANICAL ENERGY DIFFERENCES BETWEEN WALKING AND RUNNING AT DIFFERENT VELOCITIES ON A TREADMILL Sonia C. Correa, Universidade Estadual de Campinas, Brazil.

Basically walking, jogging and running are ways we transport our body from one place to another, under our own muscle power. While walking is fairly easy to distinguish from the other two, there is a lot of confusion on what is jogging and what is running. The easiest way to measure the energy cost is by measuring the work we do when we breathe. We use about five Calories per liter of Oxygen we breathe in and the more our muscles work the greater is the Oxygen demand they make and the more we need to breathe deeply and rapidly. What will qualify as jogging for him will depend on the load on his muscles and the Oxygen demand on his lungs. This is why the commonly used suggestion that jogging is the speed at which you can hold a conversation is actually a valid one. It means that the Oxygen load placed on the lungs is not that heavy so the activity qualifies as jogging and not running. Walking, for example is a low energy-cost activity but as we walk faster and faster the energy expenditure keeps on increasing. So, indeed, the moment that threshold is reached we change from walking to jogging. The amount of energy we require drops dramatically, once again. This leap from walking to jogging to running is made automatically by the body in order to optimize the way it moves and the way it uses up available energy. This is important for those who use walking or jogging as a means of maintaining their bodyweight. A fast power walk especially one where ankle or wrist weights are used is likely to burn up more Calories than a jog. A slow run may not necessarily burn up more Calories than a jog at the top range of jogging. One of the most common mistakes we make when calculating the number of Calories burnt during a walk, jog or run is not taking into account the number of Calories we would have burnt had we just stayed at home and watched TV. This is one reason why High Intensity Interval Training HIIT workouts are so effective and also why running at a challenging pace produces better results, faster than walking. After walking the body returns to the normal Base Calorie Burn almost immediately while hard running produces a state of elevated energy consumption that can persist for up to half an hour afterwards. Jogging is somewhere in-between and can sometimes deliver fewer Calorie burnt than a demanding walk performed with ankle and wrist weights. It constantly optimizes in order to reduce the energy cost. That means that if we walk the same distance every day for three months while we get better at it, it will also get easier. We will no longer burn as many Calories and we will need to increase the pace or start jogging. The same goes for jogging. At some point we need to start running. And when we run we need to find ways to challenge ourselves either by improving our speed or by increasing the distance we run or by mixing the pace or by doing the running equivalent of High Intensity Interval Training HIIT where we constantly break up the pace by going flat out and then kicking it back for a little while and then repeating. Summary While walking, jogging and running require energy to transport the body over a given distance, running has higher energy costs and also produces the fastest physiological changes, In direct difference to walking and jogging running also produces an after-burn which continues to consume calories for some time after the end of the run. From a fitness and health point of view we understand that: We need to walk more frequently and twice the distance in order to get near the energy burn of running. Jogging is more efficient than walking so at a jog we may burn fewer Calories than our top walking speed though it feels faster. Running is a constant challenge to the body and the harder we run the more energy we need to spend in order to maintain the pace. Finally, our bodies continuously change and optimize and our running regime also needs to change accordingly in order to challenge us.

Chapter 3 : The Difference Between Walking, Jogging and Running

2. Mechanical and physiological differences between running and walking at various velocities: 2.

The biomechanical and metabolic effects of prostheses and exoskeletons on walking, running, hopping, and sprinting. Currently, there are no science-based objective methods for prescribing running specific leg prostheses. We are conducting a series of studies that aim to optimize prescription of running-specific prostheses for athletes with transtibial amputations by systematically varying prosthetic stiffness and height during running and sprinting. For the first time in history, people with a lower limb amputation have regained normative function during level-ground walking due to the development of a new powered ankle-foot prosthesis. However, negotiating natural and built environments also requires the ability to walk and run on uphill and downhill slopes. We are conducting a series of studies that aim to characterize biological ankle joint function during walking and running on slopes in order to further develop advanced powered ankle-foot prostheses. There is a need for simple and unobtrusive assistive mechanical devices that can augment human performance. An assistive device such as a passive-elastic exoskeleton that could optimize energy efficiency and make it easier to carry a load or run faster with less effort has the potential to dramatically improve human locomotion. We are performing a series of studies to identify the optimal stiffness of a springy leg exoskeleton and then designing a device that is able to be used during walking and running. What is the Optimal Stiffness of a Pediatric Prosthesis? The biomechanical effects of prosthetic feet on children with a lower leg amputation are not well understood. We are studying how different pediatric prostheses affect the biomechanics of children with amputations during walking. Opportunities for Undergraduates The requirements for undergraduate students who would like research experience in our Lab are: Completed at least one year in college. Will be at CU for at least two more semesters. Available for hours of time per week in blocks of hours at a time. For more information, contact Prof. Unfortunately, due to high demand, we cannot accommodate all qualified students. Does metabolic rate increase linearly with running speed in all distance runners? Sports Medicine International Open ; ; 2: Gait and Posture 65 https: Step time asymmetry increases metabolic energy expenditure during running European Journal of Applied Physiology https: The biomechanics of the fastest sprinter with a unilateral transtibial amputation. Journal of Applied Physiology Older runners retain youthful running economy despite biomechanical differences. Characterizing the mechanical properties of running-specific lower-limb prostheses. How do prosthetic stiffness, height, and running speed affect the biomechanics of athletes with bilateral transtibial amputations? Published 28 June Prosthetic model, but not stiffness or height, affects the metabolic cost of running for athletes with unilateral transtibial amputations. Published March 30, Journal of Applied Physiology http: Reduced prosthetic stiffness lowers the metabolic cost of running for athletes with bilateral transtibial amputations. Patients with sacroiliac joint dysfunction exhibit altered movement strategies when performing a sit-to-stand task. Effects of passive and powered ankle-foot prostheses on leg joint work during sloped walking. Frontiers in Bioengineering and Biotechnology Front. What determines the metabolic cost of human running across a wide range of velocities? Journal of Experimental Biology The contributions of ankle, knee and hip joint work to individual leg work change during uphill and downhill walking over a range of speeds. The functional roles of muscles during sloped walking. Maximum-speed curve-running biomechanics of sprinters with and without unilateral leg amputations. Journal of Experimental Biology , Elite long jumpers with below the knee prostheses approach the board slower, but take-off more effectively than non-amputee athletes. Scientific Reports; ; 7:

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Thirty male subjects from two groups 15 Elite who used BR during athletic competition and 15 Athletic habitual runners performed running trials for each of the following conditions: Sagittal view high speed video Hz and force platform data Hz were obtained and the following parameters were evaluated: Intrinsic support length, ankle range of motion, knee angular velocity and impact peak time as a percentage of stance time did not change. Stance time, vertical oscillations, and resultant active peak time as a percentage of stance time decreased linearly. Seventy percent of the FRmax parameter values were greater than BRmax values, with the following exceptions: In addition, trunk angle at ground contact and resultant active peak time as a percentage of stance time showed no significant differences. Independent of velocity, the following parameters could explain the greater Elite group velocities: Forward running FR has benefitted from a great deal of investigation because, as a form of locomotion, it is the basis for a number of competitive sports as well as health and fitness activities. With topics covering cardiovascular fitness to injury mechanisms to proper mechanics for fast running, an enormous amount of time has been poured into FR research. Backward running BR , on the other hand, has not received this kind of attention. Only Bates, Morrison and Hamill have mentioned the importance of BR in sport, noting that it was done in quick bursts on athletic fields or courts. It is curious that BR has seen so little research, as it plays an important role in a number of highly competitive team sports, including football, basketball, soccer, lacrosse and other team competitions played in similar settings. In football for example, a defensive back employing BR can keep both the receiver and the quarterback in his field of vision. Once the defensive back turns to run forward, he loses sight of one if not both of these players, placing him at a disadvantage since both the quarterback and the receiver know where the ball is supposed to go. Sports like soccer, basketball, and lacrosse, and other sports where a ball travels from one end of a field or court to another and in which running is the mode of transportation are all enhanced by BR. Superior speed at BR is an advantage for the above mentioned football defensive back or a player in any of these sports, because with greater speed they can keep their eyes on the ball, the player with the ball, and or other surrounding players longer, allowing them to better defend attacks. Since high level performance in the sports listed above is lucrative business, one might think the BR aspect of sport would be thoroughly investigated so that athletes could reach their optimal BR performance. This has been done for FR in sport. But as stated above, there has been no BR research directed towards sports improvement. The topics of the limited BR research that do exist are, kinematics of BR movement at moderate velocities, and muscle force and joint moments. There has been no research aimed at improving BR performance in highly skilled athletes who use BR. The reason for this lack of BR research may be that coaches do not separate backward running as a skill that is different from forward running. A question that needs study is whether FR and BR have similar gait characteristics at high speeds maximum efforts. For example, the characteristic of maximum stride frequency may be limited by several factors, including length of limb, force production of the muscles, the task, the environmental conditions, the morphology of the individual, and a running motor program. In kinematically and kinetically comparing a maximum BR effort to a maximum FR effort, several of these factors can be controlled for and measured, helping to answer this question. This was true for joint movement patterns and joint powers. Conversely, Devita and Stribling in their investigation of lower extremity joint moment and joint muscle power with respect to BR found that BR was not simply a reversal of FR. Their results indicated the muscular structure supporting the ankle and knee reversed roles in FR and BR. Backward running is a learned skill and one that seems to have its own motor program. The average individual does not spend a lot of time performing BR. This is quite different from FR, which is developed early in life. Lundberg studied locomotion in children and found that ninety percent could run forward at 18 months, though stiffly. Normal individuals have a strong motor program for forward running FR. Currently, no study has been published recording when children learn the skill of BR. Studying how a sedentary individual performs BR may have little value. These individuals may never perform BR throughout their lives. Though BR may find some uses as a balance control exercise, athletic individuals performing some activity mainly use it. These activities may be sports or rehabilitation related. Therefore, to better study the parameters of high speed BR, individuals who are highly experienced in BR elite BR users should be used as subjects. In choosing a control group for comparison, an athletic population of skilled movers should be used, since athletically unskilled individuals might have difficulty performing BR. The hip joint is ultimately constrained in flexion by the physical contact of the quadriceps with the chest or musculo-tendonous units spanning the hip and the knee. In extension, the hip is constrained by the anterior musculo-tendonous units spanning the hip joint. There is no movement in either FR or BR that requires maximum flexion of the hip joint. However, both FR and BR can require full extension at the hip. In FR, the hip can reach full extension at or just after toe-off. In BR, the hip can reach full extension just prior to ground contact. Thus, the hip joint may constrain BR velocity by not allowing sufficient extension at ground contact. In FR, the hip joint may constrain velocity by not allowing sufficient extension at toe-off. In both directions, effective hip extension can be gained by increased trunk lean, which decreases hip angle. The knee is constrained in flexion by the physical contact of the hamstrings muscle groups with the gastrocnemius. Extension of the knee is constrained by ligaments, posterior muscles and bone. Maximum velocity of forward running may be constrained slightly in knee flexion, however, it is unlikely that increased knee extension would increase running velocity. The knee does not constrain BR in flexion, but may in extension at or near toe-off. If the knee were able to hyperextend without injury, BR ground contact time could increase, which could potentially increase propulsive force. BR requires muscular work as the knee reaches full extension at toe-off. Knee joint proprioceptors sense joint extension and send neurological signals to activate antagonistic muscles. This action avoids damage to the knee joint structure, but the antagonistic muscular force is counterproductive to BR velocity. The ankle is constrained in flexion and extension by bone, ligaments and musculo-tendonous units. It is unlikely that normal ankle ROM constrains FR reduced plantarflexion may limit the ability to produce force. Like the knee, the ankle is not constructed for backward locomotion. From the standing position, ankle plantarflexion produces forward movement. BR is thus constrained during the stance phase. In addition, as the runner moves backward, the ankle angle increases as opposed to decreasing as in FR, lessening the amount of plantar flexion available and thus limiting propulsive potential. Forward and backward running differ in their utilization of major thigh muscles during running propulsive and swing phases with respect to the hip and knee joints. During the BR propulsive phase, the rectus femoris is involved in hip flexion and the entire quadriceps group rectus femoris, vastus lateralis, medialis, and intermedius extends the knee. During the FR propulsive phase, the quadriceps group is responsible for knee extension only. Additionally, hip extension is aided by the hamstring group biceps femoris, semitendinosus, and semimembranosus. During swing phase, BR utilizes the same muscles as FR does during its propulsion phase. Conversely, FR swing phase muscular utilization is similar to the BR propulsion phase. This means that more muscles are at work in BR than in FR during the non-propulsion or resting phase. Thus, FR employs a greater muscular potential during propulsion and is muscularly more efficient during swing phase than is BR. Most of the backward walking studies have been from a motor control perspective, attempting to determine what gait parameters and motor programs were used. BR studies have been conducted primarily from an aid to injury rehabilitation viewpoint. The first published BR study came from Bates, Morrison, and Hamill who compared joint angles during BR and FR in 9 female runners at one backward and two forward running speeds. They compared equivalent speeds for BR and FR 2. BR and equivalent efforts 3. The study results indicated BR, when compared to FR, had lesser ranges of motion at both the knee and hip with respect to stance phase. This study did not measure stride rate. However, one can surmise that BR stride rate is greater than FR stride rate given decreased range of motion which should equate to decreased stance phase time of the 2. Vilensky, Gankiewicz, and Gehlsen conducted a study that employed incremental increases in backward walking velocity. Another backward walking study was conducted by Winter, Pluck, and Yang in This was true for joint movement patterns and joint power. Conversely, Devita and Stribling , in their investigation of lower extremity joint moment and joint muscle power with respect to BR, found that BR was not simply a reversal of FR. Their study used five volunteer male participants, one with experience using BR. Measurements were taken from digitized video and combined with force platform analysis including ground reaction forces. Their results indicated the muscular structure supporting the ankle and knee reversed roles in FR and BR -- During BR, the knee provided the primary power while the ankle plantarflexors absorbed shock. They had an experimental group practice BR for 8 weeks as part of a daily running routine, while a control group only practiced FR. Their study investigated BR at 3. They concluded there were significant increases in muscular strength of the knee extensors within the BR group as a result of BR training. The investigators hypothesized that the decrease in the BR group impact forces was seen because the toe landed first in BR and allowed more shock absorption than the heel that struck first in FR. Flynn and Soutas-Little investigated muscle power and action during FR and BR, analyzing the sagittal plane of the right knee. Their results indicated that during the initial stance phase of running, more work was required for FR than BR. This was found true especially for eccentric muscle contractions where four times more work was required for FR than BR. The study also noted that the participants who dropped out of BR were not the slowest at FR. All the above studies can be combined for some general conclusions. Firstly, BR and FR are not just reversals of the same movement. Secondly, an individual who possesses skill and speed in FR may not possess them in BR. Thirdly, high speed BR has not been investigated. With respect to forward running, sprinting has been extensively researched, and answers on how to improve performance have been determined and implemented.

Chapter 5 : Backward Running: Alan W. Arata, Lt. Col., Ph.D.

Biomechanical characteristics of overweight and obese children during five different walking and running velocities Â§ Meron Rubinstein The Wingate College of Physical Education and Sport Sciences, Wingate Institute, Netanya, Israel.

The present study investigated differences in the amount of muscle activity during walking, jogging, and running. The central frequency of each muscle seemed to remain essentially unchanged between running and jogging compared with walking, and fatigue did not arise. The vastus lateralis and vastus medialis of the quadriceps not only act on the lower limb during running or walking but also suppress damage to the knee during weight-bearing in the stance phase. Therefore, we speculated that the amount of muscle activity would increase as the GRF increases. The averaged values of the vastus medialis were significantly higher during running and jogging compared with walking. The present study found that the knees were flexed significantly more during running and jogging compared with walking at initial contact and during mid stance. These findings support the notion that the vastus medialis works easily during jogging and running. In addition, Kim et al. Furthermore, in a previous study 15 , we compared the muscle activity during jogging and walking at the same velocity. In this study, the activity of the vastus medialis during jogging was significantly higher, and the knee joints exhibited significant flexion during jogging. Furthermore, the lower legs exhibited external rotation and internal rotation during running Load was especially applied in the direction of internal rotation in the stance phase. A study by Ono et al. In addition, the activity of the vastus lateralis muscle during walking was significantly higher, which could account for the small difference between walking and running. We considered that the influence of knee flexion was small. The average values of the adductor muscles did not significantly differ among walking, jogging, and running. Along with the outer muscles of the hip joint such as the gluteus medius, the adductor muscles maintain the inner-outer intermediate position of the lower limb during running. The types of hip movement involved in running are primarily flexion and extension, with minimal adduction and abduction. In addition, because the treadmill floor is horizontal, the trunk is also likely to become upset. Therefore, we considered that the adductor muscles do not play significant roles in walking, jogging and running. The averages values for the tibialis anterior muscle were significantly higher during running and jogging compared with walking. The tibialis anterior muscle contracts either centrifugally or isometrically before and after initial contact to control the foot to prevent falling 18 , This muscle was significantly more contracted during running and jogging, perhaps because movement was faster. The average values of the lateral and medial heads of the gastrocnemius were significantly higher during running and jogging compared with walking. The gastrocnemius works from the loading response to the terminal stance between the stance phase The knee joint extends in the late stance phase of the running stride via plantar flexion of the ankle joint. The force exerted on the Achilles tendon during running exceeds fold the weight of the runner A large output by the gastrocnemius is required to advance the body during running. The average value of the soleus muscle was significantly higher during running than during walking. The soleus is a single joint muscle that runs from the proximal portion of the tibia and fibula to the Achilles tendon. Thus, the amount of muscle activity is not affected by the angle of the knee joint. Because the knee flexes deeply in mid stance during running, more extension is required at toe off, and thus a large force is required for the triceps surae muscle. Under such conditions, the soleus muscle works more easily than the gastrocnemius, which is a biarticular muscle. According to Mann et al. The stance phase is longer than the swing phase during walking but is shorter during running. According to Kluitenberg et al. We considered that exercise load is greater during running compared with walking due to these factors. The present study found that the amount of activity in the soleus muscle was significantly higher during running and jogging compared with the amounts of activity in the vastus medialis, tibialis anterior, and gastrocnemius muscle, which are involved in walking. Therefore, it was suggested that an increase in velocity causes these muscles to carry a heavier load. Hip and pelvis injuries in runners: Phys Sportsmed, , Does running exercise cause osteoarthritis? Md Med J, , An epidemiologic study of the benefits and risks of running. Sports and performing arts medicine. Lower-limb injuries in endurance sports. Arch Phys Med Rehabil, , Foot strike patterns and collision forces in habitually barefoot versus shod runners. 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Chapter 6 : Activity of lower limb muscles during treadmill running at different velocities

During level-ground walking, mechanical work from each leg is required to redirect and accelerate the center of mass. Previous studies show a linear correlation between net metabolic power and the rate of step-to-step transition work during level-ground walking with changing step lengths.

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relationship between mechanical and physiological energy costs and efficiency of treadmill walking in active and inactive females. k. d. browder.

Chapter 8 : Comparison of High Speed Backward & Forward Running: Alan W. Arata, Lt. Col., Ph.D.

INTRODUCTION. Human movement can be classified into walking and running, the latter of which easily fatigues the lower limb muscles 1, 2, 3, 4).During running, the lower limbs must cope with the repeated transient impact of vertical ground reaction force (GRF), which is an abrupt collision force equal to about to 3-fold the body weight 5).