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Masterclass

A comparison of the spatiotemporal parameters, kinematics, and biomechanics between shod, unshod, and minimally supported running as compared to walking

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ABSTRACT

Recreational running has many proven benefits which include increased cardiovascular, physical and mental health. It is no surprise that Running USA reported over 10 million individuals completed running road races in 2009 not to mention recreational joggers who do not wish to compete in organized events. Unfortunately there are numerous risks associated with running, the most common being musculoskeletal injuries attributed to incorrect shoe choice, training errors and excessive shoe wear or other biomechanical factors associated with ground reaction forces. Approximately 65% of chronic injuries in distance runners are related to routine high mileage, rapid increases in mileage, increased intensity, hills or irregular surface running, and surface firmness. Humans have been running barefooted or wearing minimally supportive footwear such as moccasins or sandals since the beginning of time while modernized running shoes were not invented until the 1970s. However, the current trend is that many runners are moving back to barefoot running or running in "minimal" shoes. The goal of this masterclass article is to examine the similarities and differences between shod and unshod (barefoot or minimally supportive running shoes) runners by examining spatiotemporal parameters, energetics, and biomechanics. These running parameters will be compared and contrasted with walking. The most obvious difference between the walking and running gait cycle is the elimination of the double limb support phase of walking gait in exchange for a float (no limb support) phase. The biggest difference between barefoot and shod runners is at the initial contact phase of gait where the barefoot and minimally supported runner initiates contact with their forefoot or midfoot instead of the rearfoot. As movement science experts, physical therapists are often called upon to assess the gait of a running athlete, their choice of footwear, and training regime. With a clearer understanding of running and its complexities, the physical therapist will be able to better identify faults and create informed treatment plans while rehabilitating patients who are experiencing musculoskeletal injuries due to running.

1. Introduction

The benefits attributed to running include cardiovascular and mental health, stress reduction, and enjoyment (Dugan & Bhat, 2005; Hafstad et al., 2009; Haskell et al., 1993; McWhorter et al., 2003). However, there are numerous risks associated with running as well (Bennell & Crossley, 1996). The most common risk factors related to running are musculoskeletal injuries which are often attributed to incorrect shoe choice, shoe wear, training errors, or other biomechanical factors associated with ground reaction forces. The typical runner makes choices related to shoe selection often based on personal preference, trend information, or a well intentioned running shoe store employee. Early man has been running barefoot or wearing minimally supportive footwear such as moccasins or sandals since the beginning of time (Bramble & Lieberman, 2004) while modernized running shoes were not invented until the 1970s (Lieberman et al., 2010). Since, Nike first revolutionized the running shoe in 1979; running shoes have gone through a major evolution with the most recent trend returning runners back to forefoot running with minimally supported running shoes (e.g., Vibram Fivefingers®, New Balance Minimus®, Nike Free®). Nike, re-revolutionized running shoes in 2001 with the Nike Free® "minimal" running shoe which helped spark the "minimalist movement". It is too early to accurately predict what impact this running trend will have on musculoskeletal related injuries; however, barefoot activities are natural to our bodies.

The goal of this master class article is to examine similarities and differences between shod and unshod (barefoot and minimally supported shoes) runners including spatiotemporal parameters, biomechanics, and running-related common musculoskeletal

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injuries. These running parameters will also be compared and contrasted to walking. The authors will use scientific recommendations and research articles to help inform the health care clinician to better empower them to make data informed treatment and running recommendations to the runners who sustain or hope to prevent musculoskeletal injuries.

2. Walking versus running

Human bipedal walking includes eight (8) phases of gait (Fig. 1). During all eight phases of walking gait at least one foot is in physical contact with the ground. During the initial contact, loading response, and preswing phases of walking gait both feet are in contact with the ground at the same time (Center, 2001). Running has similar gait sequences as compared to walking such as stance period absorption and propulsion (Dugan & Bhat, 2005) as well as the functional tasks of weight acceptance, single limb support, and swing limb advancement. Although running is a natural extension of walking, it has many dissimilarity that must be considered when treating the running athlete (Pink, 2010a,b). Fig. 1 compares the similarities and dissimilarities of walking and running gait.

Running differs from walking by certain characteristics such as the increased velocity or distance travelled per unit time and the presence of an airborne or float phase (Dugan & Bhat, 2005; Pink, 2010a,b). Even at the same speed, race walking is differentiated from running in that the later lacks double limb support and has a float phase (Dugan & Bhat, 2005). Runners have four distinct phases or events of running gait: 1) stance, 2) early swing or float, 3) middle swing, and 4) late swing or float (Fig. 1) (Pink, 2010a,b; Pink, Perry, Houglum, & Devine, 1994; Reber, Perry, & Pink, 1993). Running phases can be further delineated; the number of these subdivisions varies depending on the running speed. Seventy-eight (78) subdivisions have been identified during slower Level I running (Brody, 1987) during shod treadmill and over ground running (pace = slower than 8 min mile or speed = slower than 7.5 mph). These slow running subdivisions include: 1) stance = 29, 2) early swing = 10, 3) middle swing = 29, and 4) late swing = 10 subdivisions (Pink et al., 1994). During shod faster Level II running (Brody, 1987) (pace = greater than 7.5 min mile or speed = faster than 8.0 mph) in recreational runners, 72 subdivisions have been identified: 1) stance = 24, 2) early swing = 12, 3) middle swing = 24, and 4) late swing = 12 subdivisions (Pink et al., 1994). During running gait analysis it is impractical to focus on deviations by subdivision; the authors recommend assessment by running phase. Dugan and Bhat (2005) and others (Pink et al., 1994) have further demarcated these 4 phases of running gait, to match the 8 phases of walking gait (Dugan & Bhat, 2005). Although these phases of running gait occur in all runners, the subdivisions vary during

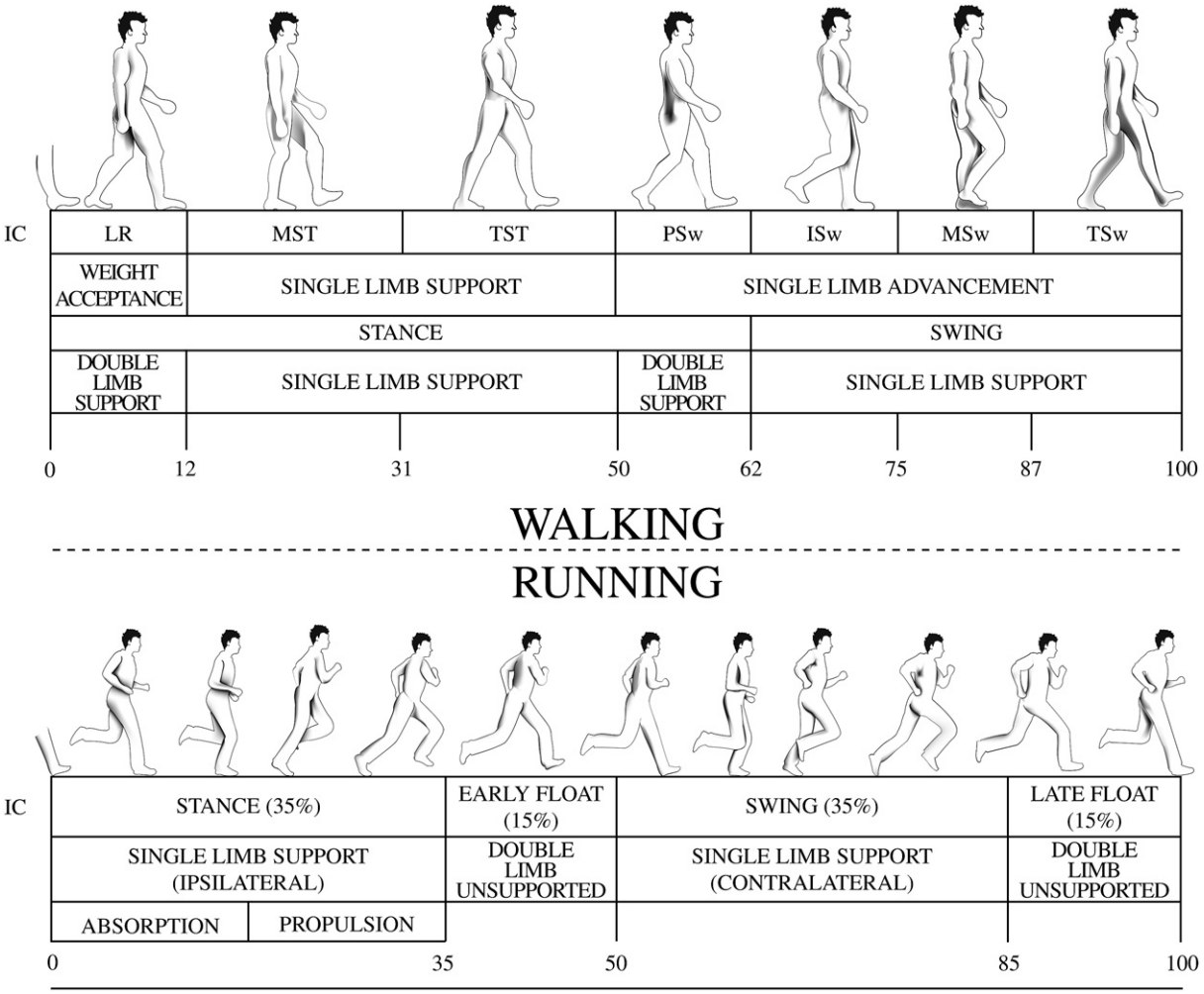

Fig. 1. Comparison of the phases of the walking and running cycles: Initial Contact (IC), Midstance (MST), Terminal Stance (TST), Preswing (PSw), Initial swing (ISw), Midswing (MSw), and Terminal swing (TSw).