

건강한 달리기 습관을 위해 살펴볼 것 — ACSM 인포그래픽 자세히 보기

Heather K. Vincent, Ph.D., FACSM; Kevin R. Vincent, Ph.D., M.D., FACSM

[Article + Infographic](#)

Supporting Literature:

Adams D, et al. Altering cadence or vertical oscillation during running: effects on running related injury

factors. *Int J Sports Phys Ther.* 2018 Aug;13(4):633-642.

Almeida MO, Davis IS, Lopes AD. Biomechanical differences of foot-strike patterns during running: a

systematic review with meta-analysis. *J Orthop Sports Phys Ther.* 2015 Oct;45(10):738-55

Apte S, Prigent G, Stoggl T, Martniez A, Snyder C, Gremaux-Bader V, Aminian K. Biomechanical Response

of the Lower Extremity to Running-Induced Acute Fatigue: A Systematic Review. *Front Physiol.* 2021 Aug

27;12:64604

Barton CJ et al. Running retraining to treat lower limb injuries: a mixed-methods study of current evidence synthesised with expert opinion. *Br J Sports Med.* 2016 May;50(9):513-26.

Bowersock CD, Willy RW, DeVita P, Willson JD. Independent effects of step length and foot strike pattern

on tibiofemoral joint forces during running. *J Sports Sci.* 2017a Oct;35(20):2005-2013.

Bowersock CD, Willy RW, DeVita P, Willson JD. Reduced step length reduces knee joint contact forces

during running following anterior cruciate ligament reconstruction but does not alter inter-limb asymmetry. *Clin Biomech (Bristol, Avon).* 2017b Mar; 43:79-85.

Bowser BJ, Fellin R, Milner CE, Pohl MB, Davis IS. Reducing impact loading in runners: a one-year Follow-

up. *Med Sci Sports Exerc.* 2018 Dec;50(12):2500-2506.

Burke A, Dillon S, O'Connor S, Whyte EF, Gore S, Moran KA. Risk factors for injuries in runners: a systematic review of foot strike technique and its classification at impact. *Orthop J Sports Med.* 2021

Sep 9;9(9):23259671211020283

Boyer ER, Derrick TR. Select injury-related variables are affected by stride length and foot strike style

during running. *Am J Sports Med.* 2015 Sep;43(9):2310-7.

Bramah C et al. A 10% increase in step rate improves running kinematics and clinical outcomes in

runners with patellofemoral pain at 4 weeks and 3 months *Am J Sports Med.* 2019

Dec;47(14):3406-

3413.

Bramah C, Preece SJ, Gill N, Herrington L. Is there a pathological gait associated with common soft tissue

running injuries? *Am J Sports Med.* 2018 Oct;46(12):3023-3031.

Brindle RA, Milner CE, Zhnag S, Fitzhugh EC. Changing step width alters lower extremity biomechanics

during running. *Gait Posture.* 2014 Jan;39(1):124-8.

Bruijn SM, Meijer OG, van Dieën JH, Kingma I, Lamothe CJC. Coordination of leg swing, thorax rotations, and pelvis rotations during gait: The organisation of total body angular momentum. *Gait Posture* 2008, 27(3): 455–462.

Busa MA, Lim J, van Emmerik REA, Hamill J. Head and Tibial Acceleration as a Function of Stride Frequency and Visual Feedback during Running. *PLoS One*. 2016 Jun 7;11(6):e0157297.

Chan ZYS, Zhang JH, Au IPH, An WW, Shum GLK, Ng GYF, Cheung RTH. Gait retraining for the reduction of injury occurrence in novice distance runners: 1-year follow-up of a randomized controlled trial. *Am J Sports Med*. 2018 46 (2):388-395.

Chan ZYS, Zhang JH, Ferber R, Shum G, Cheung RTH. The effects of midfoot strike gait retraining on impact loading and joint stiffness. *Phys Ther Sport* 2020 Mar;42:139-145.

Charlton JM et al. Learning gait modifications for musculoskeletal rehabilitation: applying motor learning principles to improve research and clinical implementation. *Phys Ther*. 2021 Feb 4;101(2):pzaa207.

Cheung RTH, Davis IS. Landing pattern modification to improve patellofemoral pain in runners: a case series. *J Orthop Sports Phys Ther* 2011. 41(12):914-919

Chumanov ES, Wille CM, Michalski MP, Heiderscheit BC. Changes in muscle activation patterns when running step rate is increased. *Gait Posture* 2012, Jun; 36(2):231-5.

Cromwell HP and Davis IS. Gait retraining to reduce lower extremity loading in runner. *Clinical biomechanics* 2011; 26 : 78-83.

Delgado TL, Kubera-Shelton E, Robb RR, Hickman R, Wallmann HW, Dufek JS. Effects of foot strike on low back posture, shock attenuation, and comfort in running. *Med Sci Sports Exerc*. 2013 Mar;45(3):490-6.

Derrick TR, Hamill J, Caldwell GE. Energy absorption of impacts during running at various stride lengths. *Med Sci Sports Exerc*. 1998, 30:128

Diebal AR, Gregory R, Alitz C, Parry Gerber J. Forefoot running improves pain and disability associated with chronic exertional compartment syndrome. *Am J Sports Med*. 2012 May;40(5):1060-7.

Dos Santos AF, Nakagawa TH, Sarrao FV, Ferber R. Patellofemoral joint stress measured across three different running techniques. *Gait Posture*. 2019 Feb; 68:37-43.

Farina KA, Jahn ME. Increasing step rate affects rearfoot kinematics and ground reaction forces during running. *Biology (Basel)*. 2021 Dec 21;11(1):8.

Futrell EE, Gross KD, Resiman D, Mullineaux DR, Davis IS. Transition to forefoot strike reduces load rates more effectively than altered cadence. *J Sport Health Sci*. 2020 May;9(3):248-257.

Fujita R, Ota S, Ogawa Y, Ota H. Effects of walking with a "draw-in maneuver" on the knee adduction moment and hip muscle activity. *J Phys Ther Sci* . 2021 Apr;33(4):329-333.

Fyock M, Cortes N, Hulse A, Martin J. Gait retraining with real-time visual feedback to treat patellofemoral pain in adult recreational runners: a critically appraised topic. *J Sport Rehabil*. 2019 Nov 7;29(5):675-679

Haghighat F, Ebrahimi S, Rexaie M, Shafiee E, Shokouhyan SM, Motealleh A, Parnianpour M. Trunk, pelvis, and knee kinematics during running in females with and without patellofemoral pain Gait Posture. 2021 Sep; 89:80-85.

Hamner SR, Delp SL. Muscle contributions to fore-aft and vertical body mass center accelerations over a range of running speeds. *J Biomech* 2013, 46(4):780-787.

Heiderscheit BC, Chumanov ES, Michalski MP, Wille CM, Ryan MB. Effects of step rate manipulation on joint mechanics during running. *Med Sci Sports Exerc* 2011;43:296-302.

Hinrichs RN. Upper extremity function in running. II: Angular momentum considerations. *International Journal of Sport Biomechanics*, 1987 3(3), 242-263.

Hobara H, Sato T, Sakaguchi M, Sato YT, Nakazawa K. Step frequency and lower extremity loading during running. *Int J Sports Med*. 2012 Apr;33(4):310-3.

Huang Y, Xia H, Chen G, Cheng S, Chueng RTH, Shull PB. Foot strike pattern, step rate, and trunk posture combined gait modifications to reduce impact loading during running. *J Biomech*. 2019 Mar 27; 86:102-109.

Kilgore 3rd, JE, Vincent KR, Vincent HK. Correcting foot crossover while running. *Curr Sports Med Rep*. 2020 Jan;19(1):4-5.

Lenhart RL, Smith CR, Vignos MF, Kaiser J, Heiderscheit BC, Thelen DG. Influence of step rate and quadriceps load distribution on patellofemoral cartilage contact pressures during running. *J Biomech*. 2015 Aug 20;48(11):2871-8

Lenhart R, Thelen D, Heiderscheit B. Hip muscle loads during running at various step rates. *J Orthop Sports Phys Ther*. 2014 Oct;44(10):766-74, A1-4.

Lieberman DE, Venkadesan M, Webel WA, Daoud AI, D'Andrea S, Davis IS, Mang'eni RO, Pitsiladis Y. Foot strike patterns and collision forces in habitually barefoot versus shod runners. *Nature* 2010; 463: 531-535

Mass E, De Brie J, Vanfleteren R, Hoogkamer W, Vanwanseele B. Novice runners show greater changes in kinematics with fatigue compared with competitive runners. *Sports Biomech*. 2018 Sep;17(3):350-360.

Mercer JA, Devita P, Derrick TR, Bates BT. Individual effects of stride length and frequency on shock attenuation during running. *Med Sci Sports Exerc*. 2003;35:307

Miller EM, Cromweel MS, Morris JB, Mason JS, Zifchock, Goss DL. Gait retraining improves running impact loading and function in previously injured U.S. military cadets: a pilot study. *Mil Med*. 2021 Nov 2;186(11-12):e1077-e1087

Milner CE, Davis IS, Hamill J. Free moment as a predictor of tibial stress fracture in distance runners. *J Biomech* 2006, 39(15):2819–2825.

Mohler F, Fadillioğlu C, Stein T. Fatigue-related changes in spatiotemporal parameters, joint kinematics and leg stiffness in expert runners during a middle-distance run. *Front Sports Act Living*. 2021; 3: 634258.

Musgjerd T, Anason J, Rutherford D, Kernozek TW. Effect of increasing running cadence on peak impact force in an outdoor environment. *Int J Sports Phys Ther*. 2021 Aug 1;16(4):1076–1083.

Noehren B, Scholz J, Davis I. The effect of real-time gait retraining on hip kinematics, pain and function in subjects with patellofemoral pain syndrome. *Br J Sports Med*. 2011;45(9):691–696.

Nunes GS, Pizzari T, Neate R, Barton CJ, Semciw A. Gluteal muscle activity during running in asymptomatic people. *Gait Posture*. 2020 Jul; 80:268–273.

Pahn X, Grisbrook TL, Wernli K, Stearne SM, Davey P, Ng L. Running quietly reduces ground reaction force and vertical loading rate and alters foot strike technique. *J Sports Sci*. 2017 Aug;35(16):1636–1642.

Pohl MB, Mullineaux DR, Milner CE, Hamill J, Davis IS. Biomechanical predictors of retrospective tibial stress fractures in runners. *J Biomech* 2008, 41(6), 1160–1165.

Roper J, Harding E, Doerfler D, Dexter J, Kravitz L, Dufek J, Mermier C. The effects of gait retraining in runners with patellofemoral pain: A randomized trial. *Clin Biomech* 2016, 35: 14–22.

Schubert AG, Kempf J, Heiderscheit BC. Influence of stride frequency and length on running mechanics: a systematic review. *Sports Health*. 2014 May;6(3):210–7.

Seay J, Scott Selbie W, Hamill J. In vivo lumbo-sacral forces and moments during constant speed running at different stride lengths. *J Sports Sci*. 2008 Dec;26(14):1519–29.

Shih H, Teng H, Gray C, Poggemiller M, Tracy I, Lee A. Four weeks of training with simple postural instructions changes trunk posture and foot strike pattern in recreational runners. *Phys Ther Sport* 2019 Jan; 35:89–96.

Stergiou N, Bates BT, Kurz MJ. Subtalar and knee joint interaction during running at various stride lengths. *J Sports Med Phys Fitness*. 2003 Sep; 43(3):319–26.

Teng H, Powers CM. Sagittal plane trunk posture influences patellofemoral joint stress during running. *Orthop Sports Phys Ther*. 2014 Oct;44(10):785–92.

Thein-Nissenbaum JM, Thompson EF, Chumanov ES, Heiderscheit BC. Low back and hip pain in a postpartum runner: applying ultrasound imaging and running analysis. *J Orthop Sports Phys Ther*, 2012 Jul;42(7):615–24.

Vanatta, Kernozek TW, Ghiedi N. Changes in gluteal muscle forces with alteration of footstrike pattern during running, *Gait & Posture*. 2017; 58:204–245.

Van Oeveren BT, de Ruiter CJ, Beek PJ, van Dieen JH. The biomechanics of running and running styles: a synthesis. *Sports Biomech.* 2021. DOI:10.1080/14763141.2021.1873411

Vincent HK, Vincent KR. Abdominal bracing for minimizing excessive pelvic motion during running. *Curr Sports Med Rep.* 2018 Apr;17(4):111.

Vincent HK, Massengill C, Harris A, Chen C, Wasser JG, Bruner M, Vincent KR. Cadence impact on cardiopulmonary, metabolic and biomechanical loading during downhill running. *Gait Posture.* 2019 Jun; 71:186-191

Wang J, Luo Z, Dai B, Fu W. Effects of 12-week cadence retraining on impact peak, load rates and lower extremity biomechanics in running. *Peer J.* 2020 Aug 24;8:e9813.

Warrener A, Tamai R, Lieberman DE. The effect of trunk flexion angle on lower limb mechanics during running. *Hum Mov Sci.* 2021 Aug; 78:102817.

Wellenkotter J, Kernozek TW, Meardon, Suchomel T. The effects of running cadence manipulation on plantar loading in healthy runners. *Int J Sports Med.* 2014 Aug;35(9):779-84.

Whitney KE, Sugimoto D, d'Hemecourt CA, DA d'Hemecourt, PA d'Hemecourt. Running gait biomechanics in female runners with sacroiliac joint pain. *J Phys Ther Sci.* 2022 Apr;34(4):327-334.

Willson J, Davis I. Lower extremity mechanics of females with and without patellofemoral pain across activities with progressively greater task demands. *J Clin Biomech* 2008, 23: 203-11.

Willson JD, Kernozek TW, Arndt RL, Reznichuk DA, Straker JS. Gluteal muscle activation during running in females with and without patellofemoral pain syndrome. *Clin Biomech (Bristol, Avon).* 2011 Aug;26(7):735-40.

Willson JD, Ratcliff OM, Willy RW. Influence of step length and landing pattern on patellofemoral joint kinetics during running. *Scand J Med Sci Sports.* 2015 Dec;25(6):736-43.

Willy RW, Willson JD, Clowers K, Baggaley M, Murray N. The effects of body-borne loads and cadence manipulation on patellofemoral and tibiofemoral joint kinetics during running. *J Biomech.* 2016 Dec 8;49(16):4028-4033.

Willy RW, Davis IS. Varied response to mirror gait retraining of gluteus medius control, hip kinematics, pain, and function in 2 female runners with patellofemoral pain. *J Orthop Sports Phys Ther.* 2013 Dec; 43(12):864-74.

Willy RW, Scholz JP, Davis IS. Mirror gait retraining for the treatment of patellofemoral pain in female runners. *Clin Biomech Bristol Avon.* 2012;27(10):1045-1051.

Willson JD, Sharpee R, Meardon SA, Kernozek TW. Effects of step length on patellofemoral joint stress in female runners with and without patellofemoral pain. *Clin Biomech (Bristol, Avon).* 2014 Mar;29(3):243-7.

Willwacher, S., Goetze, I., & Fischer, K. M. The free moment in running and its relation to joint loading

Winter, D. Moments of force and mechanical power in jogging. *J Biomech.* 1983, 16:91-97.

Winter S, Gordon S, Watt K. Effects of fatigue on kinematics and kinetics during overground running: a systematic review. *J Sports Med Phys Fitness.* 2017 Jun;57(6):887-899.

Xia H, Huang Y, Chen G, Cheng S, Cheung RTH, Shull PB. Self-selected running gait modifications reduce acute impact loading, awkwardness, and effort. *Sports Biomech.* 2021 Jun 9;1-14.

Yong JR, Silder A, Montgomery KL, Fredericson M, Delp SL. Acute changes in foot strike pattern and cadence affect running parameters associated with tibial stress fractures. *J Biomech.* 2018 Jul 25; 76:1-7.

Yu P, Liang M, Feket G, Baker JS, Gu Y. Effect of running-induced fatigue on lower limb mechanics in novice runners. *Technol Health Care.* 2021;29(2):231-242.

Injury risk in runners

Almeida MO, Davis IS, Lopes AD. Biomechanical differences of foot-strike patterns during running: a systematic review with meta-analysis. *J Orthop Sports Phys Ther.* 2015 Oct;45(10):738-55.

Becker J, Nakajima M, Wu WFW. Factors contributing to medial tibial stress syndrome in runners: a prospective study. *Med Sci Sports Exerc.* 2018 Oct;50(10):2092-2100.

Johnson CD, Tenforde AS, Outerleys J, Reilly J, Davis IS. Impact-related ground reaction forces are more strongly associated with some running injuries than others. *Am J Sports Med.* 2020 Oct;48(12):3072-3080.

Kliethermes SA, Stiffler-Joachim MR, Wille CM, Sanfilippo JL, Zavala P, Heriderscheit BC. Lower step rate is associated with a higher risk of bone stress injury: a prospective study of collegiate cross country runners. *Br J Sports Med.* 2021 Aug;55(15):851-856.

Luedke LE, Heiderscheit BC, Williams DSB, Rauh MJ. Influence of step rate on shin injury and anterior knee pain in high school runners. *Med Sci Sports Exerc.* 2016 Jul;48(7):1244-50.

Pohl MB, Hamill J, Davis IS. Biomechanical and anatomic factors associated with a history of plantar fasciitis in female runners. *Clin J Sport Med.* 2009 Sep;19(5):372-6.

Menendez C, Batalla L, Prieto A, Rodriguez MA, Crespo I, Olmedillas H. Medial tibial stress syndrome in novice and recreational runners: a systematic review. *Int J Environ Res Public Health.* 2020 Oct 13;17(20):7457.

Milner CE, Ferber R, Pollard CD, Hamill J, Davis IS. Biomechanical factors associated with tibial stress fracture in female runners. *Med Sci Sports Exerc* 2006 Feb;38(2):323-8.

Mousavi SH, Hijmans JM, Rajabi R, Diercks R, Zwerver J, van der Worp H. Kinematic risk factors for lower limb tendinopathy in distance runners: A systematic review and meta-analysis. *Gait Posture* 2019 Mar; 69:13-24.

Neal BS, Barton CJ, Gallie R, O'Halloran P, Morrissey D. Runners with patellofemoral pain have altered biomechanics which targeted interventions can modify: A systematic review and meta-analysis. *Gait Posture*. 2016 Mar; 45:69-82.

Whitney KE, Sugimoto D, d'Hemecourt CA, d'Hemecourt DA, d'Hemecourt PA. Running gait biomechanics in female runners with sacroiliac joint pain. *J Phys Ther Sc*. 2022 Apr;34(4):327-334.