Chapter 16
Rocker profiles

Juha M. Hijmans, Roy Reints and Laurens van Kouwenhove

Keymessage

With rocker profiles the biomechanics of gait can be altered. Proximally placed forefoot rockers can reduce the forces on the Achilles tendon and when combined with a stiff foot plate, strain on the plantar fascia can be reduced. These proximal rockers can also reduce the pressure at the Metatarsal Phalengeal (MTP) region. By adjusting the apex and rocker angle and rocker radius, plantar pressure and Achilles tendon and plantar fascia force reduction can be individually optimized. Rocker profiles can also reduce the ankle joint motion during the heel- and ankle rocker and, combined with a stiff foot plate, rocker profiles can eliminate the motion in the MTP-joints.

Introduction

A rocker bottom shoe can be defined as: 'a shoe with an outsole rocker bar or a contoured outsole creating a curved anteroposterior profile'. In daily practice rocker profiles are used very often. However, the impression exists that the design is limited to the apex positions, proximal, at, or distal of the MTP-region. In this chapter some research will be described that also shows the importance of other properties of the rocker profile, as these properties of the profile determine the biomechanical effects of the shoe. Shape properties that can be altered in a rocker profile are (Figure 16.1):

- *Apex position*, usually determined/represented as a percentage of the shoe length measured from the heel.
- *Apex angle*, which is the angle between the rocker apex and the longitudinal axis.
- *Rocker angle*, the angle between the part of the shoe distal to the apex and the ground.
- *Rocker radius*, which is the curve of the rocker.

These properties can be applied to both the heel rocker, and the forefoot rocker. In figure 16.1 the shape properties are depicted. The stiffness of the rocker profile also influences the biomechanics of gait. A stiffer sole prevents dorsiflexion of the toes where a flexible sole allows this motion. In

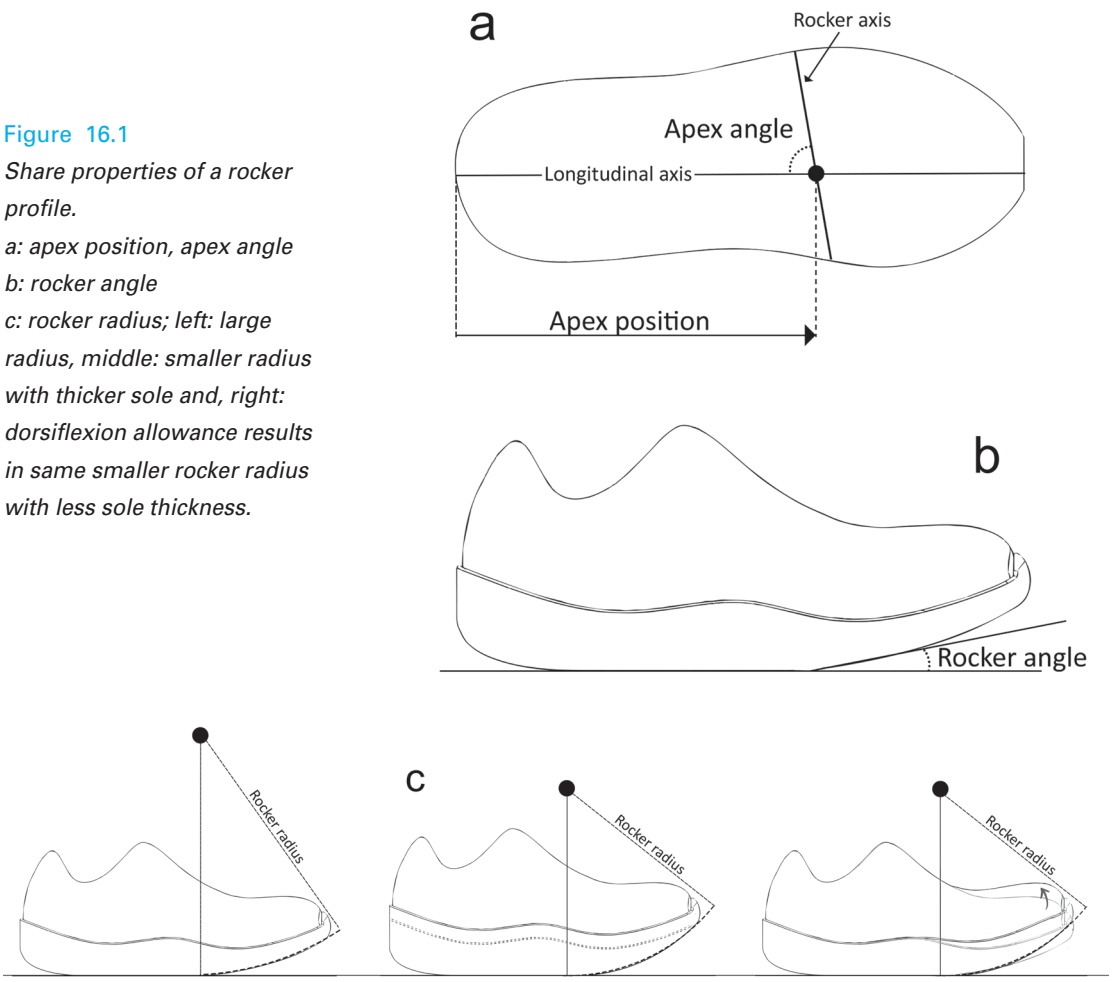

Figure 16.1
Share properties of a rocker profile.
a: apex position, apex angle
b: rocker angle
c: rocker radius; left: large radius, middle: smaller radius with thicker sole and, right: dorsiflexion allowance results in same smaller rocker radius with less sole thickness.

the following paragraphs known effects of a rocker profile on biomechanics are described. The biomechanical parameters relate to kinematics (movements, angles and range of motion), kinetics (moments and powers around the joint) and pressure distribution.

Pressure

Pressure is the force applied perpendicular to the surface of an object per unit area over which that force is distributed. In other words; pressure equals to the force divided by the area. Rocker profiles can be used to redistribute high pressures that occur at a certain location across other locations underneath the foot.[1] Therefore, rocker profiles are commonly used in the prevention of diabetes related foot ulcers and in metatarsalgia with pressure related pain.

Multiple studies have used in-shoe pressure measurement systems to determine the effects of different rocker properties on plantar pressures. These systems use multiple pressure sensors

An apex angle above 90° in general will lead to better offloading of the medial forefoot region whereas an apex angle below 90° will lead to the opposite effect, offloading the lateral forefoot region. According to Preece et al. (2017) an optimal rocker design would incorporate an apex angle of 95°, an apex position of 52% of shoe length and a rocker angle of 15° or 20°.[4]

Flexibility of the rocker profile & plantar pressure

Traditionally rocker profile shoes are made with a stiff foot plate, diminishing change of shape of the rocker profile and preventing dorsiflexion of the toes. In a study where rocker profile shoes with an apex position of 50% and 60% of the shoe length, an apex angle of 85° and a removable carbon foot plate, it was shown that stiff rocker shoes reduced plantar pressure in the MTP region more than flexible rockers.[7] With both apex positions pressure under the first toe increased more when a stiff rocker was applied.

The shoes used in this study allowed for dorsiflexion of the sole but not for plantar flexion as this is thought to increase pressure when the shape of the shoe flattens during the third rocker. The dorsiflexion is allowed because of cuts that were made in the sole (Figure 16.3).

Kinetics: apex position & forces on Achilles tendon and plantar fascia

As described earlier, with the use of rocker profile shoes, the application point of the GRF at the start of the third rocker will be at the apex. When the apex is positioned more proximal, the application point of GRF is shifted in proximal direction, reducing the arm of the sagittal plane ankle moment. As a strong relation exists between the force applied to the Achilles tendon and plantar fascia and the internal plantar flexion moment, proximally

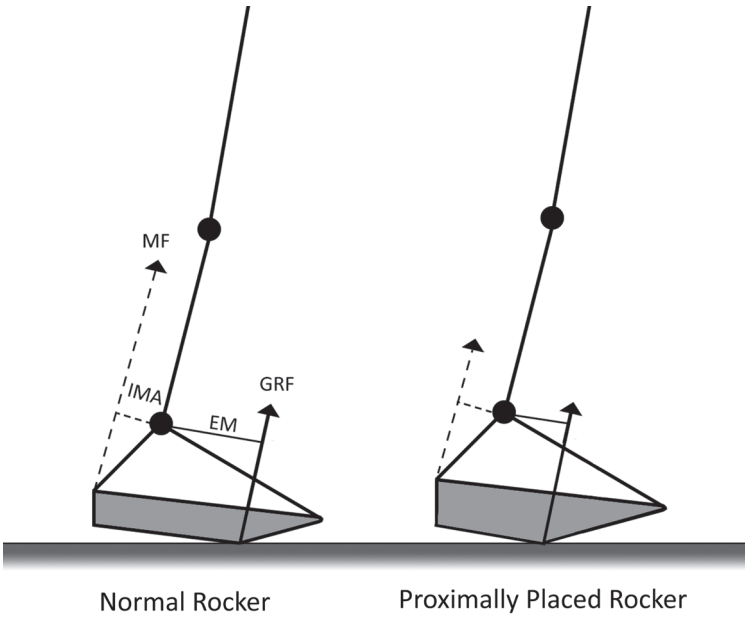

Figure 16.4
Biomechanical effect of a rocker profile with a proximal apex position. The external moment arm (EM) is reduced with a proximal apex position. Therefore, the external moment is reduced. As the internal moment is reduced, the force on the Achilles tendon is also reduced.

References

1. Postema, K., Burm, P. E., Zande, M. E. et al. (1998). Primary metatarsalgia: the influence of a custom moulded insole and a rockerbar on plantar pressure. Prosthetics and Orthotics International, 22(1), 35–44.
2. Bus S.A., Haspels R., Busch-Westbroek T.E. (2011) Evaluation and optimization of therapeutic footwear for neuropathic diabetic foot patients using in-shoe plantar pressure analysis. Diabetes Care. 34(7):1595-600.
3. Chapman, J. D., Preece, S., Braunstein, B. et al. (2013). Effect of rocker shoe design features on forefoot plantar pressures in people with and without diabetes. Clinical Biomechanics, 28(6), 679–685.
4. Preece, S. J., Chapman, J. D., Braunstein, B. et al. (2017). Optimisation of rocker sole footwear for prevention of first plantar ulcer: comparison of group-optimised and individually-selected footwear designs. Journal of Foot and Ankle Research, 10(1), 27.
5. Nawoczenski, D.A., Birke, J.A., Coleman W.C. (1988) Effect of rocker sole design on plantar forefoot pressures. Journal of the American Podiatric Medical Association, 78(9), 455-460.
6. Sobhani, S., van den Heuvel, E., Bredeweg, S. et al. (2014). Effect of rocker shoes on plantar pressure pattern in healthy female runners. Gait and Posture, 39(3), 920–925.
7. Reints, R., Hijmans, J. M., Burgerhof, J. G. M. et al. (2017). Effects of flexible and rigid rocker profiles on in-shoe pressure. Gait and Posture, 58(August), 287–293.
8. Hutchins, S., Bowker, P., Geary, N. et al. (2009, September). The biomechanics and clinical efficacy of footwear adapted with rocker profiles-Evidence in the literature. Foot, 19(3):165-70.
9. Sobhani, S., van den Heuvel, E. R., Dekker, R. et al. (2017). Biomechanics of running with rocker shoes. Journal of Science and Medicine in Sport, 20(1), 38–44.
10. Arazpour, M., Hutchins, S. W., Ghomshe, F. T. et al. (2013). Effects of the heel-to-toe rocker sole on walking in able-bodied persons. Prosthetics and Orthotics International, 37(6), 429–435.