Human Movement Science 42 (2015) 246–260

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

The influence of breast support on torso, pelvis and arm kinematics during a five kilometer treadmill run

Alexandra Milligan *, Chris Mills, Jo Corbett, Joanna Scurr

Department of Sport and Exercise Sciences, Spinnaker Building, University of Portsmouth, PO1 2ER, United Kingdom

ARTICLE INFO

Article history:
Available online 14 June 2015

PsycINFO Classification:
3720

Keywords:
Female
Running
Kinematics
Cardan angles

ABSTRACT

Many women wear sports bras due to positive benefits associated with these garments (i.e. reduction in breast movement and breast pain), however the effects these garments have on upper body running kinematics has not been investigated. Ten female participants (32DD or 34D) completed two five kilometer treadmill runs (9 km h^{-1}), once in a low and once in a high breast support. The range of motion (ROM) and peak torso, pelvis, and upper arm Cardan joint angles were calculated over five gait cycles during a five kilometer run. Peak torso yaw, peak rotation of the pelvis, peak pelvis obliquity, ROM in rotation of the pelvis, and ROM in upper arm extension were significant, but marginally reduced when participants ran in the high breast support. The running kinematics reported in the high breast support condition more closely align with economical running kinematics previously defined in the literature, therefore, running in a high breast support may be more beneficial to female runners, with a high breast support advocated for middle distance runners.

1. Introduction

Reducing the magnitude of breast kinematics relative to the torso is a unique issue for the female athlete. Without effective breast support, the breast tissue moves independently to the torso, with a

* Corresponding author at: Department of Sport and Exercise Science, University of Portsmouth, Spinnaker Building, Cambridge Road, Portsmouth PO1 2ER, United Kingdom. Tel.: +44 (0)2392 84 3085.

http://dx.doi.org/10.1016/j.humov.2015.05.008
0167-9457/

significant time-lag evident between the torso and breast during running (Scurr, White, & Hedger, 2009). Research studies within breast biomechanics have investigated; the direction and magnitude of breast kinematics during running (Scurr et al., 2009; White, Scurr, & Smith, 2009), the number of females exercising in appropriate breast support (Bowles, Steele, & Munroe, 2008), the relationship between breast kinematics and exercise-related breast pain (McGhee, Steele, & Power, 2007; Scurr, White, & Hedger, 2010), the number of females who identify breast movement as a barrier to physical activity (Bowles, Steele, & Munro, 2008), and how the direction and magnitude of breast kinematics can inform breast support design (Scurr et al., 2010; Starr, Branson, Shehab, Ownby, & Swinney, 2005). However, few papers have considered the impact of breast support on human movement.

Without muscle or bone, the breast tissue may be described as a wobbling mass situated on a rigid torso segment. A female of a 34D bra size has an additional mass of approximately 920 g (460 g per breast) (Turner & Dujon, 2005) situated on the torso segment. Due to the location of the breast it is important to consider how the magnitude of independent movement of this additional mass may influence the kinematics of the torso and other upper body segments during exercise. Many have argued that the energetic cost of running is influenced by segment structure, for example, a segment with a greater distribution of mass from the axis of rotation, specifically at the distal end (Martin & Morgan, 1992; Myers & Steudel, 1985; Taylor, Shkolnik, Dmi'el, Baharav, & Borut, 1974) will have a greater moment of inertia, and will therefore require greater torque to rotate the segment about its axis. This argument is based on the notion that a substantial portion of metabolic demand during running is associated with accelerating and decelerating the limbs with each stride (Martin & Morgan, 1992). Dependent upon the amount of compression and elevation provided, a breast support may distribute the breast tissue differently over the torso, with the breast tissue assumed to be more proximal to the torso and more compressed to the chest wall in a sports bra. Without adequate breast support, the breast tissue may be located closer to the distal end of the torso and further away from the chest wall, with less restriction of independent movement (McGhee, Steele, Zealey, & Takacs, 2013; Scurr et al., 2010), which may therefore influence the kinematics of the torso during running.

Within gait literature the relationships between segments are emphasised (Novacheck, 1998), with efficient energy transfer between segments equating to economical running mechanics and a reduced metabolic cost (Williams & Cavanagh, 1987). In order to maintain a constant velocity during running, counter-rotation occurs between the pelvis and torso, which enables an individual to maintain a constant step length and frequency (Bruijn, Meijer, van Dieën, Kingma, & Lamoth, 2008; Novacheck, 1998). The role of the pelvis in energy conservation has been emphasised by Schache, Bennell, Blanch, and Wrigley (1999), suggesting that the degree of anteroposterior tilt at the pelvis should be minimised to conserve energy and maintain efficiency in running. Furthermore, Schache et al., 1999 proposed that the degree of pelvic obliquity (the deviation of the pelvis from the horizontal in the frontal plane) plays a role in shock absorption during the running gait cycle. With every foot strike a shock wave is transmitted throughout the body, reaching the upper body and head, which results in soft tissue vibrations (Hamill, Derrick, & Holt, 1995; Mercer, Vance, Hreljac, & Hamill, 2002). Without muscle to dampen these vibrations at the breast, it may be desirable for a female runner to attenuate the shock wave before it reaches the torso, reducing potential breast movement associated with ground contact. As a result of the different magnitudes of independent breast movement and exercise-related breast pain experienced across breast support conditions (Scurr et al., 2010; Scurr, White, & Hedger, 2011; McGhee et al., 2013), the kinematics of the pelvis, that contribute to natural shock absorption, may differ between breast support conditions as a strategy to reduce the magnitude of independent breast movement.

Arm swing is a distinctive characteristic of walking and running, with the magnitude and frequency defined as compensatory and synchronous with the action of the legs (Eke-Okoro, Gregoric, & Larsson, 1997; Hinrichs, 1990; Pontzer, Holloway, Raichlen, & Lieberman, 2008). For example, during sprinting leg mechanics are forceful and explosive, the arms must move in large controlled flexion and extensions at the shoulder to support the increase in velocity (Hinrichs, 1990). As the pace is slowed, the arms move through shorter arcs and swing across the torso toward the midline of the body (Hinrichs, 1990). There are many benefits of arm swing reported in the literature; it has been shown that the arms serve to reduce fluctuations in mediolateral and anteroposterior displacement of the center of mass during running, improving energy costs (Bruijn, Meijer, Beek, & van Dieën, 2010;