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PREVENTION & REHABILITATION: Editorial

Linking the limb girdles – Mobility & motor control

1. Introduction

In this section, we welcome contributions from Morley and Traum (2019) and from Hernandez et al. (2019), as well as a guest editorial with applied practical insights from Diane Lee.

Morley and Traum (2019) build on their 2016 paper (Morley and Traum, 2016), this time investigating how compromising spinal mobility affects energy consumption and vertical movement of the body during running gait. Hernandez et al. (2019) explore the difference between a general exercise program for older people with knee osteoarthritis and a more targeted core stability program.

Diane Lee then takes the research findings from these two studies and illustrates how these findings relate closely to a deeper understanding of the importance of optimizing function and load transfer through the thoracic spine and rib cage.

2. Dorso-lumbar restriction & gait

In the April 2016 Edition of JBMT, Morley & Traum presented a paper called *The effects of dorso-lumbar motion restriction on the ground reaction force components during running* (Morley and Traum, 2016). This excellent contribution was discussed in some detail in the accompanying editorial “Toe-tal recall – what on Earth are our toes for?” investigating how their findings correlated with Gracovetsky's (1988) Spinal Engine theory.

In this edition, Morley & Traum revisit a similar research methodology, looking at how use of a fitted brace to minimize motion in the thoraco-lumbar region affects running efficiency and gross kinematics. Interestingly, in the run coaching world, it has been observed that long-distance runners often tend toward one of two strategies – described colloquially as “gliders” and “gazelles” (for example, see Dunn, 2019). Gliders tend to take more of a transverse plane strategy to move forwards, through rotating their trunk and taking shorter strides. Gliders, therefore, may be described as taking more of a trunk dominant or transverse plane strategy. Gazelles tend to take more of a leg-dominant or sagittal plane strategy to move forward; bounding with a higher displacement of the centre of mass resulting in a greater vertical sin-wave motion and thereby utilising the elastic mechanisms of the lower limb in particular. We discuss the potential ramifications of this in the “Toe-tal Recall” paper. (Wallden, 2016).

It would follow that restricting the ability of the spine to rotate would encourage the “Gazelle” leg-dominant style of running, yet Morley and Traum (2019) found that in the motion-restricted condition subjects exhibited less vertical displacement of the center of mass, thereby running with more of a “gliding” gait pattern. There may be several reasons for this finding; one being the fact that the runners assessed in this study were not running long distances (running for just 5 minutes), so may have used a different running strategy to the observations described by running coaches.

Interestingly, Morley & Traum (2019) found that there was a greater vertical loading force at heel strike, suggesting a more leg-dominant drive, yet this did not translate to greater vertical displacement of the centre of mass. One possible rationale for this relates to Gracovetsky's description of the importance of lordosis in his Spinal Engine mechanism. Gracovetsky (2001) explains that immediately after heel-strike, as the ground reaction forces travel up the leg and meet with the descending inertial forces of the head, arms and trunk, the lordosis is at its maximum. In effect, under normal circumstances, the lumbar spine will flex axially (driving relative lumbar sagittal extension and lordosis) upon loading, creating sacral nutation. This loading is checked passively via the immensely strong sacro-spinous and sacro-tuberous ligaments, and actively via the gluteus maximus, hamstring group and, to some degree, the lower abdominals (see Fig. 1).

Recoil from this axial flexion will spring the body's centre of mass upward and forward in the gait cycle, however, if this lordosis is minimized by extrinsic restriction, such as the brace utilised in Morley & Traum's study, the body must compensate. One interpretation, therefore, of Morley and Traum's (2019) findings is that due to the artificial restriction on this spring mechanism due to the trunk cast, downward inertial forces and upward ground reaction forces must be compensated for elsewhere in the kinematic chain; in this instance seemingly at the foot, knee and hip, thereby maintaining a lower centre of mass during the gait cycle. The higher impact forces detected in the casted condition supports this notion.

As Morley and Traum (2019) point out, this could contribute to earlier onset of fatigue and increased risk of overuse injury.

A further possible explanation for the decreased vertical translation of the centre of mass in the casted state is that, in spite of the cast, runners may have still be utilising a transverse plane (gliding) strategy. In their methodology, Morley & Traum explain that the cast they utilised ran from the sacrum up to approximately T7, thereby restricting the motion segments in this region by approximately 53%. However, as Gracovetsky demonstrates (see Fig. 2), spinal rotation in gait in the mid-to upper thoracic spinal segments. Since the brace only restricted half of the spine's motion and more than half of spinal rotation occurs above T7, casted runners may still have been able to adopt a transverse plane strategy – and may have preferentially chosen this strategy due to the reduction in shock absorbing or energy conversion properties of the casted lumbar segments.

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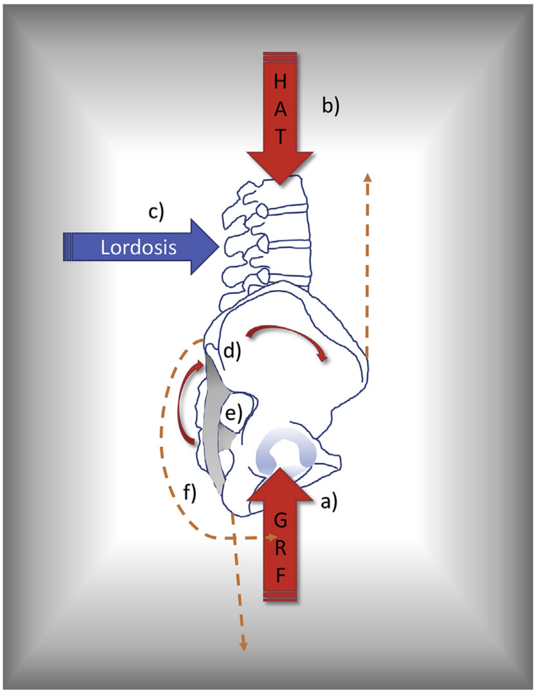

Fig. 1. Under normal circumstances in gait, as the a) Ground Reaction Force (GRF) travels up the lower limb, it meets with the b) inertial forces of the Head, Arms & Trunk (HAT) at the pelvis. The c) lumbar lordosis undergoes axial flexion (relative sagittal extension) ensuring that these forces create d) sacral nutation which is checked passively by the e) sacrotuberous and sacrospinous ligaments, driving anterior pelvic tilt. This anterior pelvic tilt is checked actively by the f) gluteus maximus, hamstrings and lower abdominals (dotted arrows). This spring mechanism and the meeting of the two opposed forces results in an upward drive of the trunk displacing the center of mass upward for the flight phase of the next step in gait.
If the ability of the lumbar spine to axially flex (sagittally extend) is restricted by a spinal brace (as occurred in the experimental condition), then utilization of this lordotic spring mechanism will be compromised, the ascending ground reaction forces must be dampened by the joints and muscles of the lower limb, and the degree of upward motion of the center of mass will be compromised - as found by Morley and Traum (2019) in their study.

Another consideration is that some longer distance runners prefer to utilise nasal respiration to keep their pace within the aerobic zone and minimize the risk of venturing into anaerobic metabolism which is not sustainable over endurance distances (Douillard, 1990). The use of the respirometry equipment forced, by its nature, mouth breathing - which alters respiratory dynamics and, as such, the relationship between diaphragmatic and transversus abdominis excursion. This impact, as described in their paper, may have been further compounded by wearing the brace. Since gait and respiration are phase-locked at performance paces (Wallden, 2017), it is likely that any alteration in respiration will affect the kinematics of gait.

3. Osteoarthritis of the knee – getting to the core of the matter

In the second paper in this section, Hernandez et al. (2019) divided 47 patients diagnosed with osteoarthritis of the knee into an experimental group receiving a self-paced staged progression of core stability exercises plus standard knee rehabilitation exercise, versus a control group who received only the standard knee rehabilitation exercises. Both groups improved in pain levels and physical function, but the core stability group experienced a statistically and clinically significant reduction in pain.

What these findings imply is that the cumulative micro-stress

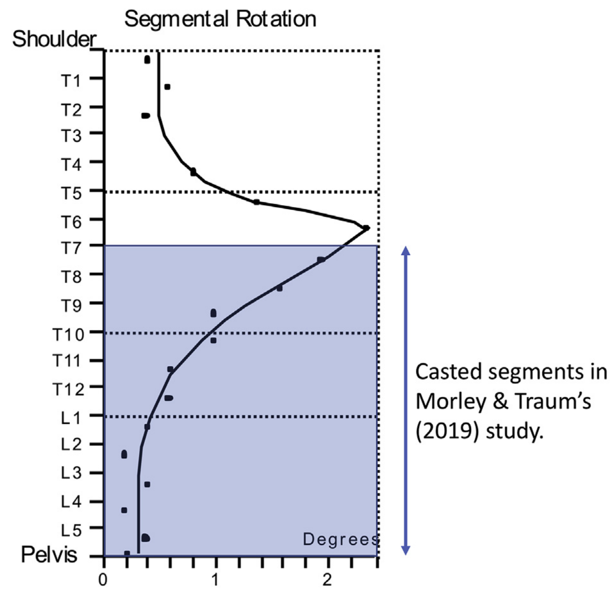

Fig. 2. Gracovetsky (2001) showed that most of the spine's axial rotation in gait occurs in the mid-thoracic spine. In their research, Morley and Traum (2019) utilised a cast to restrict spinal motion (by a mean 53%) between the pelvis and approximately T7 (shaded area) meaning that much of the segmental rotation of the spine was still available; thereby potentially allowing for a transverse plane strategy in gait which minimizes upward displacement of the center of mass.

that leads to osteoarthritic changes is not localised to and around the knee. As kinematic modelling has suggested for decades, and this research appears to reaffirm, osteoarthritis of a given joint is not likely to be due to local biomechanical challenges alone.

Importantly, Hernandez et al. (2019) identified a clinically significant reduction in pain behavior in all subjects over the intervention period, plus clear reduction in NSAID use which statistically and clinically favoured the core stability group, both at the end of the treatment and one month after the intervention had ceased. These two findings have important ramifications for the integrated role of core stability exercises in both the psychological and the biochemical impact on patients with osteoarthritis.

Interestingly, the right knee was more affected than the left knee in the cohort, with an average across the two groups of 61.7% having osteoarthritis in the right knee, and 38.3% in the left knee. In the papers “Laterality” (Wallden, 2011) and “The Middle Crossed Syndrome – New Insights into Core Function” (Wallden, 2014), a clinical pattern which has been observed was described, where right handed/right footed individuals tend toward medial rotational instability in their dominant (kicking) leg and a corresponding inhibition or deconditioning of their oblique sling systems from the same hip to the opposite shoulder.

If this observation is accurate, we would expect to see a bias toward cumulative stress and osteoarthritic change in the right knee in a right footed population. Since Hernandez et al. (2019) did not report on handedness/footedness dominances in their paper it is not possible to know if the trend toward right knee osteoarthritis in this group related to laterality and the middle-crossed pattern described by Wallden (2014).

In the general population, left footedness has an incidence of approximately 10% (Loffing et al., 2016). With this in mind, if the cohort gathered by Hernandez et al. (2019) are representative of the general population, we would expect that approximately 5 of the group would be left footed and more likely to develop osteoarthritic changes in their left knee. Hence, we can calculate that, of the remaining 42 right footed participants, 68% experienced osteoarthritic changes to the expected knee based on the middle-crossed model. Comparing this to what should be expected due to chance alone (ie 68% observed versus 50% if by chance) we can safely surmise that the pattern proposed by the middle-crossed syndrome model trends strongly toward what it predicts.

In conclusion then, both the work of Hernandez et al. (2019) and of Morley and Traum (2019) in this section can be seen to add weight to earlier clinical models proposed by Gracovetsky (1988) and Wallden (2011, 2014) and, as conveyed by Lee and Wallden (2019), the importance of optimal function of the kinematic link between the pectoral and pelvic girdles is key; both in terms of mobility and in terms of motor control. The body's integrated nature, and the importance of utilising multiple tools, including motion testing and mobilisation, motor control and movement retraining, as well as psychological and biochemical considerations are imperative if our aim is to help clients to the best of our abilities to realise their performance potential.

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