Biomechanics of dart-throwing motion (DTM)

Educational article - English edition

Read the article and view its resources on the IFTM website

Source article: Moritomo H et al. 2007 IFSSH committee report of wrist biomechanics committee: biomechanics of the so-called dart-throwing motion of the wrist. J Hand Surg Am. 2007;32(9):1447-1453.

This report by the IFSSH wrist biomechanics committee reviews dart-throwing motion (DTM), a functional oblique wrist movement from radial extension to ulnar flexion. It considers anatomical, biomechanical, functional, anthropological and clinical perspectives.

DTM is presented as the wrist's principal functional plane in daily activity. Rather than pure movement in sagittal and frontal planes, most physiological tasks use an oblique combination of extension with radial deviation and flexion with ulnar deviation. The authors recommend the terms "radial extension" and "ulnar flexion" rather than "radial deviation-extension" and "ulnar deviation-flexion".

Historical development

In the nineteenth century, Henke, Corson and Fick had already observed that carpal movement followed oblique rather than strictly orthogonal axes passing through the capitate. In 1956, Capener clearly identified DTM as the principal physiological wrist plane in striking and tool-use tasks. He also noted slight pronation accompanying radial extension and slight supination accompanying ulnar flexion.

The authors emphasise that DTM predominantly involves the midcarpal rather than radiocarpal joint. This may explain its stability, smoothness and functional efficiency.

Articular factors

The scaphotrapeziotrapezoid (STT) complex has a central role. The oblique contour of the distal scaphoid surface guides STT movement around an axis close to DTM. Asymmetric capitate geometry also favours oblique rather than strictly sagittal movement. Other features include the obliquity of the scapholunate concavity, the C-shaped midcarpal joint and the guiding roles of the triquetrum and hamate.

Ligament factors

The scaphocapitate (SC) and STT ligaments are described as the main ligamentous guides. Their arrangement resembles collateral ligaments of an oblique uniaxial joint. By contrast, the capitolunate joint is relatively unconstrained, while the triquetrohamatocapitate ligaments mainly limit terminal movement.

Muscle factors

The main DTM motors are flexor carpi ulnaris and extensor carpi radialis longus and brevis. Dynamic stabilisation is provided by extensor carpi ulnaris and flexor carpi radialis, whose tendon paths coincide with the overall DTM axis.

Proprioceptive factors

The authors report few mechanoreceptors in the STT and SC ligaments, whereas structures limiting terminal DTM are richly innervated. This suggests a predominantly mechanical role for STT and SC ligaments, with terminal capsuloligamentous structures contributing to proprioception and motor control.

Modern biomechanical studies

The report reviews electrogoniometry, electromagnetic systems, three-dimensional MRI, volumetric registration and three-dimensional in-vivo kinematics. DTM differs between individuals, is generally oriented 30-45° to the sagittal plane and permits greater range than pure flexion-extension.

The principal kinematic finding is markedly reduced scaphoid and lunate movement. Werner and colleagues found that scaphoid movement may account for only 26% of overall movement and lunate movement approximately 22% in certain specific oblique planes. Crisco and colleagues identified a plane near 45° minimising scaphoid movement and one near 30° minimising lunate movement.

These findings suggest specific rehabilitation planes that preserve functional movement while limiting radiocarpal loading.

Anthropological perspective

DTM is presented as important in human evolution through throwing, tool use, percussion and clubbing activities. It improves energy transfer, increases terminal speed and amplifies the lever arm in striking movements.

Clinical implications

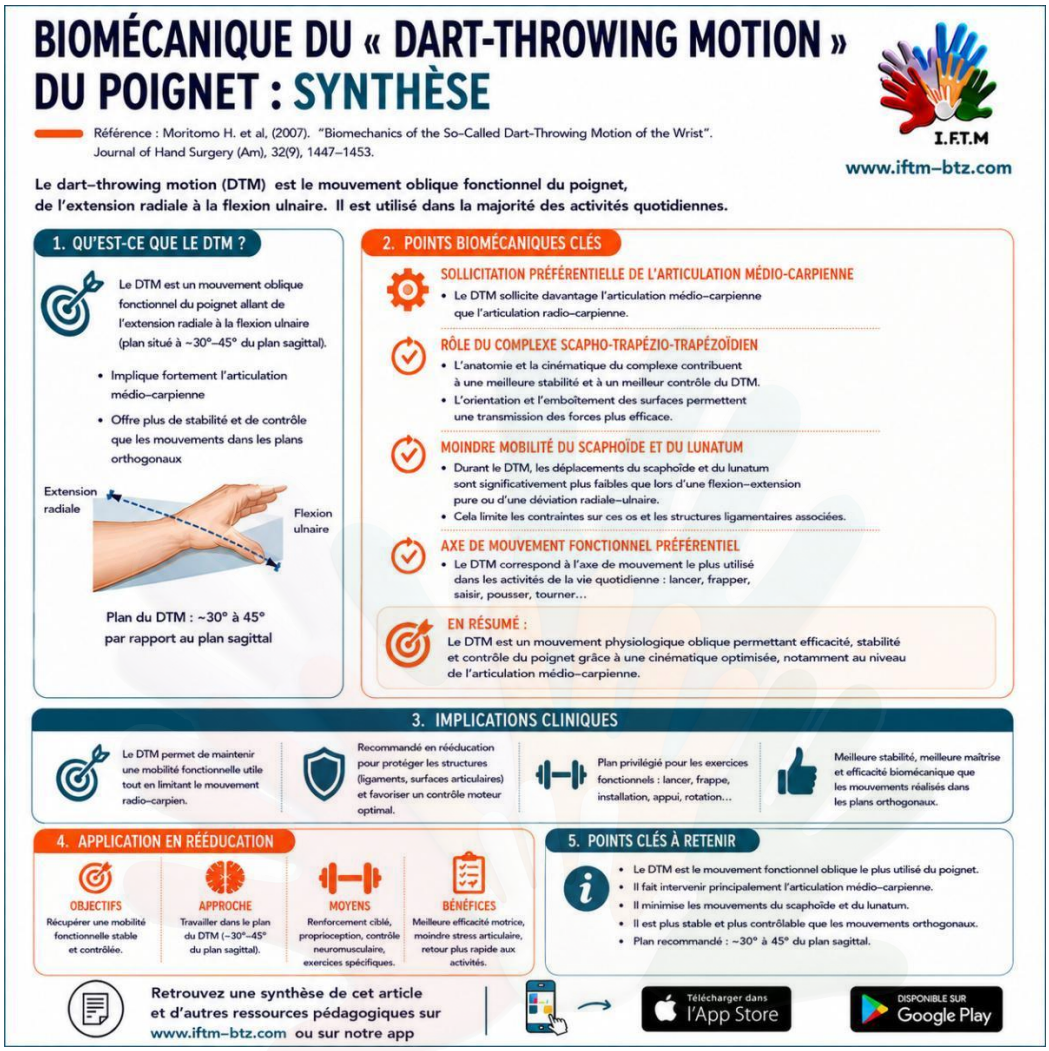
The authors suggest that preserving midcarpal mobility is essential to maintaining DTM. Certain radiocarpal fusions might preserve satisfactory function through retained DTM. Rehabilitation directed in the DTM plane might allow early mobilisation while limiting loading of the scaphoid, lunate and scapholunate ligaments.

Finally, DTM should be regarded as a whole-upper-limb movement involving the wrist, forearm rotation, elbow and shoulder.

The report concludes that DTM is the wrist’s principal functional plane, preferentially involves the midcarpal joint and minimises scapholunate movement. It has major biomechanical, functional, evolutionary and clinical significance. Its optimal orientation varies between individuals and according to the mechanical objective.

Illustrations from the original resource

Figure 1



Original illustration reproduced without redrawing. Any text within the image remains in its original language. Refer to the article for sources and interpretation.