Biomechanical Principles of Common Orthotic Treatment Concepts for Gait Problems in Cerebral Palsy – A Critical Consideration

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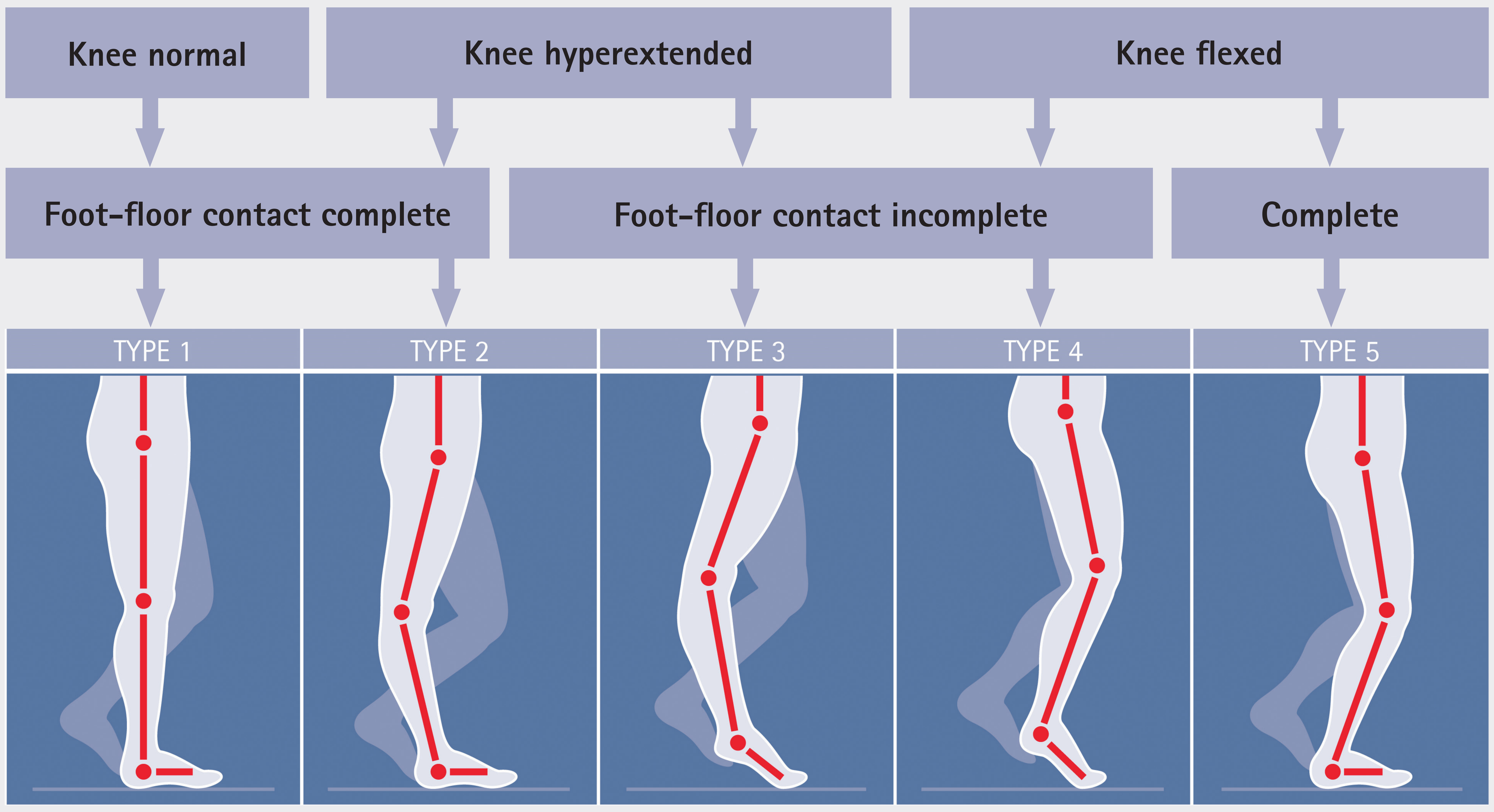
Aims

The major goal of an orthotic treatment in cerebral palsy (CP) is to come closer to a physiological gait. An ankle foot orthosis (AFO) prepares the foot for initial contact, enables stability and supports the ankle's push-off. It should have a positive effect on therapy, reduce energy consumption and must not block remaining physiological motion.

The Amsterdam Gait Classification evaluates knee position and foot-floor contact in mid stance in order to determine the requirements for an orthotic treatment.

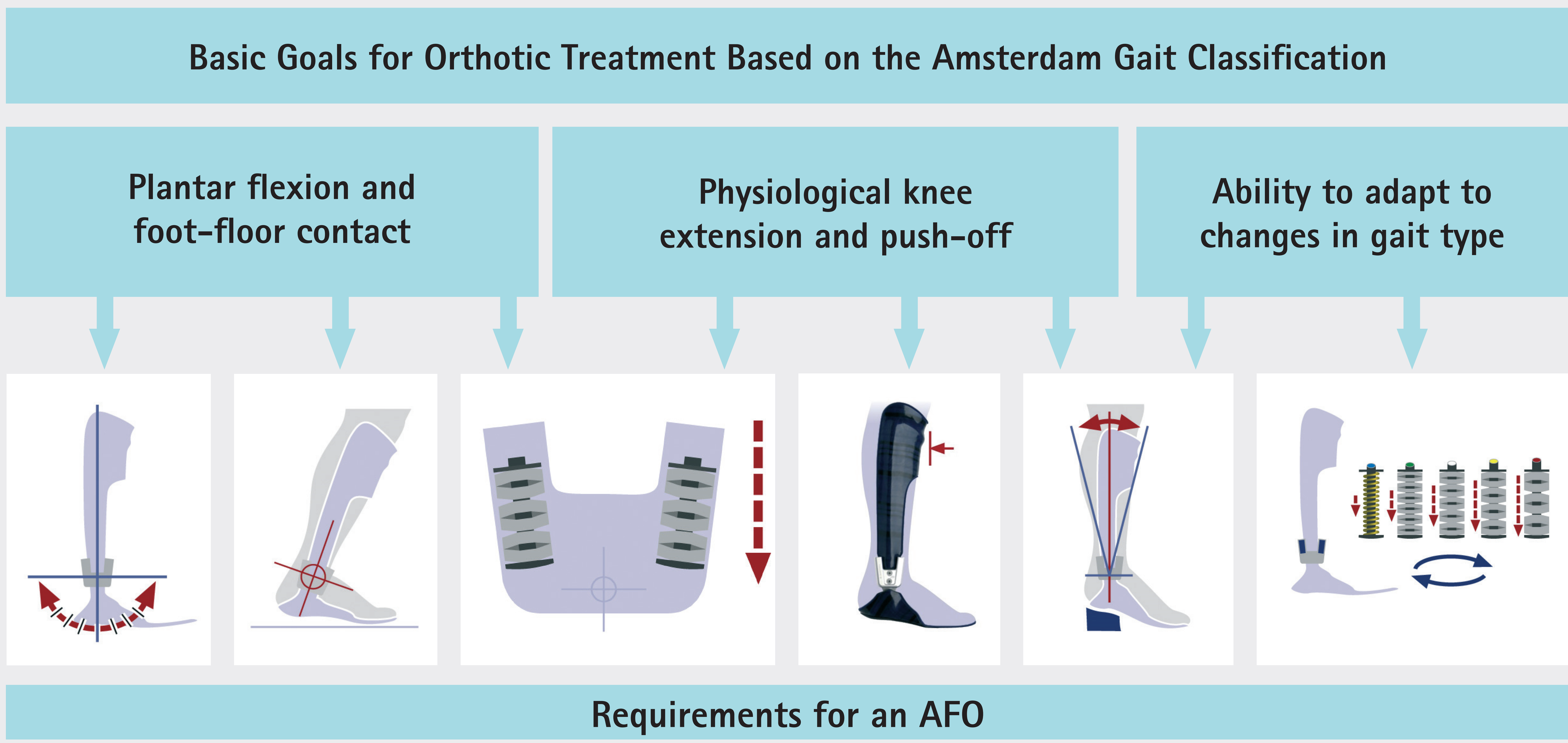
Respecting the gait types of the Amsterdam Gait Classification, a detailed consideration of existing AFO types should indicate whether all requirements for an effective orthotic treatment can be met.



Methods

The effects of common AFOs are evaluated. The basic goals of an orthotic treatment result from the Amsterdam Gait Classification: allowing plantar flexion, establishing physiological foot-floor contact and knee extension, supporting push off. Additionally, the AFO should be adjustable to changes of the gait. Certain biomechanical features of an AFO help to achieve these goals.

Considering criteria of adjustable range of motion, defined pivot point, spring force, shell design and adjustable alignment, solid AFO (SAFO), dynamic AFO (DAFO), floor reaction AFO (FRAFO), posterior leaf spring AFO (PLS AFO) and hinged AFO (HAFO) are compared.



Results

	Adjustable Alignment	Adjustable Range of Motion	Plantar Flexion Possible	Variable Spring Force	High Spring Force	Defined Pivot Point
SMO	✗ not after manufacturing	✗ not possible	✗ if achilles tendon is not free ✓ if achilles tendon is cut free in AFO	✗ not after manufacturing	✗ not possible	✓
DAFO	✗ not after manufacturing	✗ not possible	✗ high force carbon fibre AFO ✓ polypropylene AFO	✗ not after manufacturing	✗ polypropylene AFO ✓ high force carbon fibre AFO	✗ not possible
SAFO	✗ not after manufacturing	✗ not possible	✗ not applicable	✗ not possible	✗ not applicable	✗ not applicable
Hinged AFO	✗ not adjustable joints (elastomere) ✓ adjustable joints	✗ not adjustable joints (elastomere) ✓ adjustable joints	✗ built-in PF-stop in joints w\ low force ✓ joints with appropriate spring force	✗ not adjustable joints (elastomere) ✓ adjustable joints	✗ elastomere or coil spring joints ✓ e. g. disc spring joints	✓
FRAFO	✗ not after manufacturing	✗ not possible	✗ not possible	✗ not after manufacturing	✗ elastomere or coil spring joints ✓ carbon-fibre, rigid sole and stiff ankle	✗ stiff ankle type ✓ hinged type FRAFO
Posterior-Leaf-Spring AFO	✗ not after manufacturing	✗ not possible	✗ not possible	✗ not after manufacturing	✓	✗ not possible

Discussion

Due to an appropriate orthosis, coming closer to a physiological gait and improving energy consumption is possible for children with CP. Common AFOs do not fulfil all necessary rquirements because basic adjustment possibilities are missing (see results).
Gait types 3 to 5 of the Amsterdam Gait Classification require high to extra high spring forces in the ankle joint in addition to a ventral shell for achieving physiological knee extension in mid stance. Due to changes in gait the spring forces must be variable.

Passive plantar flexion in loading response depends on adjustable range of motion and a defined pivot point. Resulting eccentric muscle work supports therapy. The correct alignment of the orthosis using biomechanical principles is essential, especially when tuning the AFO.

The resulting demand is: Both dynamic and static AFOs should be produced with an adjustable ankle joint!

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References

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