The Flexibility Trainer

Biomechanical analysis of martial arts kick performances for user centred product development

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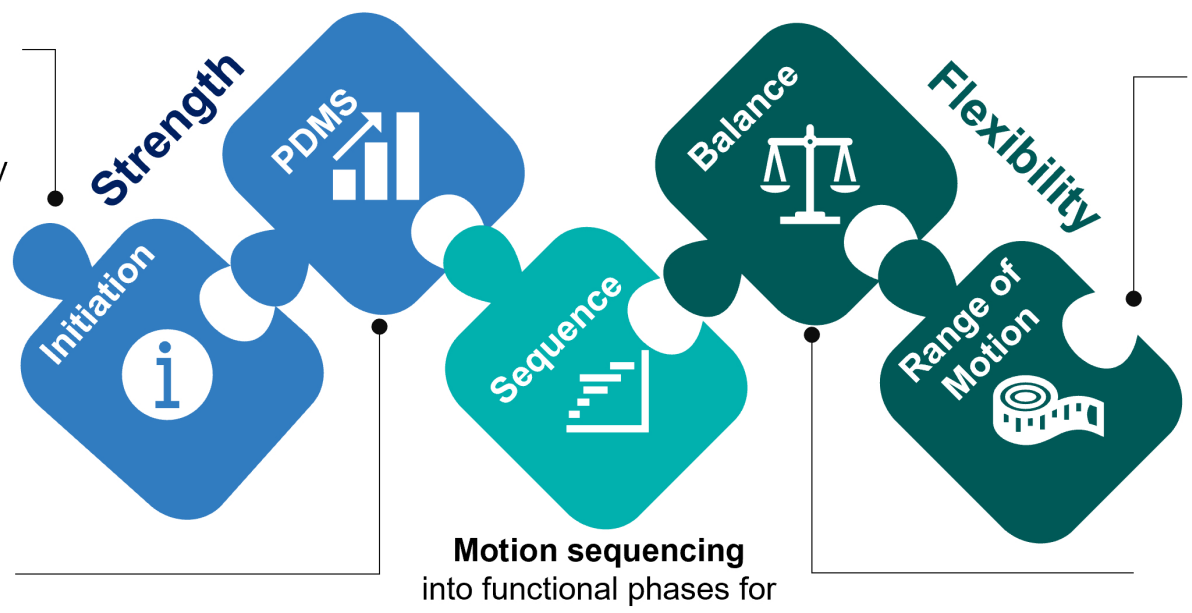
Kinematic technique analysis to extract pre-requisites

Kick technique analysis for pre-requisite extraction

Initiation **a**ctions (**IA**) are performed to generate power but are also the first part of a movement which can be detected by an opponent.

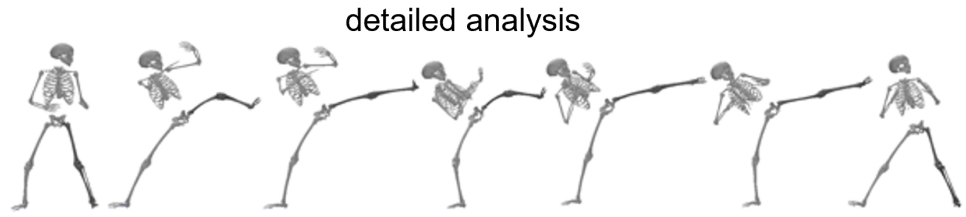


Proximal-to-**D**istal **M**ovement **S**equences (**PDMS**) describe the power transfer from the pelvis to the target.

Motion sequencing into functional phases for detailed analysis

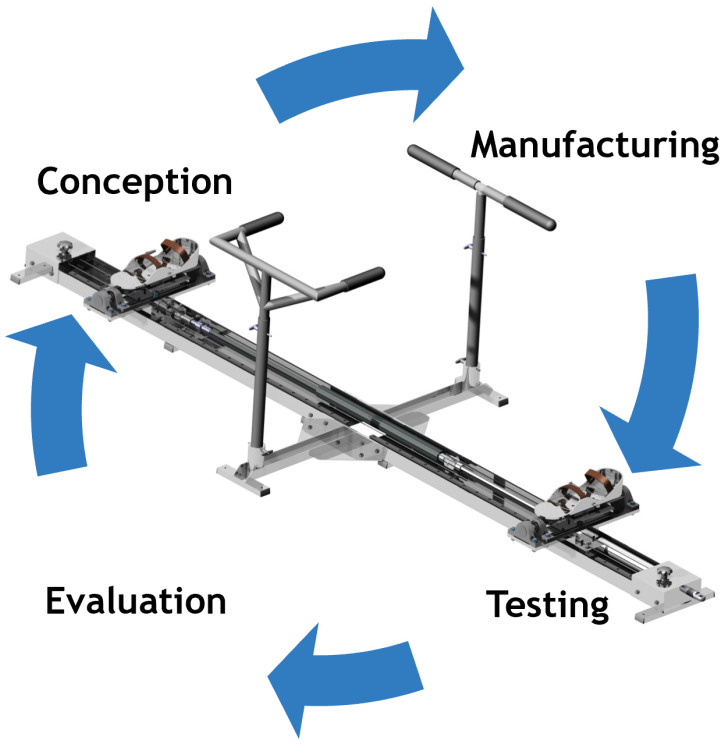
Balance and **stab**ility behavior during technique execution determined by novel mathematical models.

Flexibility and **R**ange **o**f **M**otion (**ROM**) determined by **V**ector **S**preading **A**ngle (**VSA**) analysis model (see below).

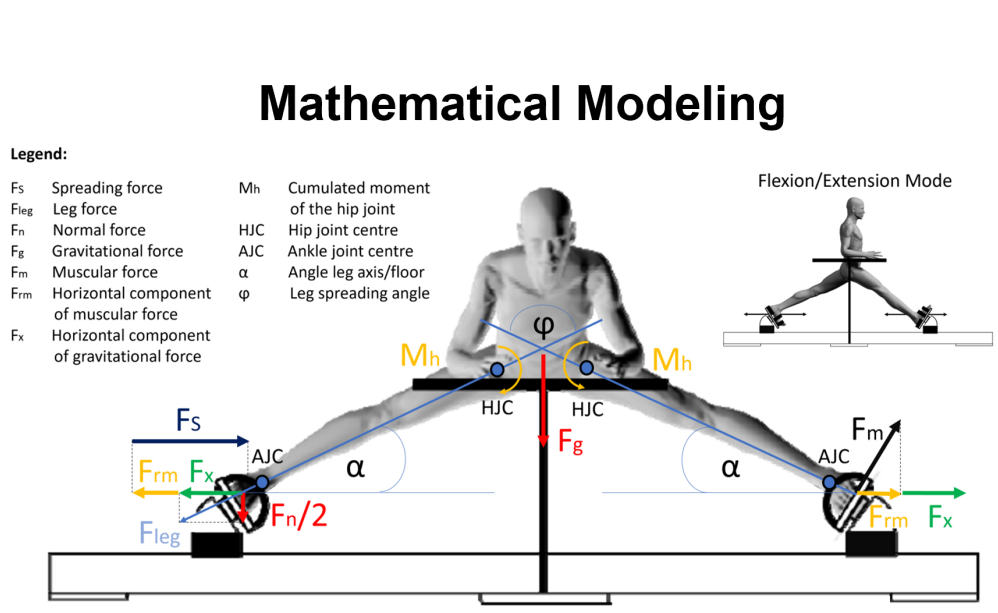


Double side kick

Design and manufacturing of user-centred prototype



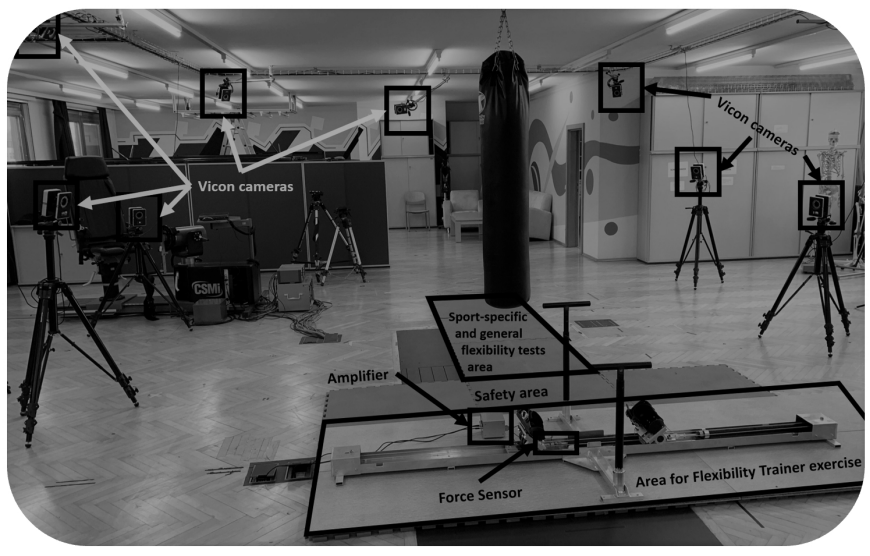
Mathematical Modeling



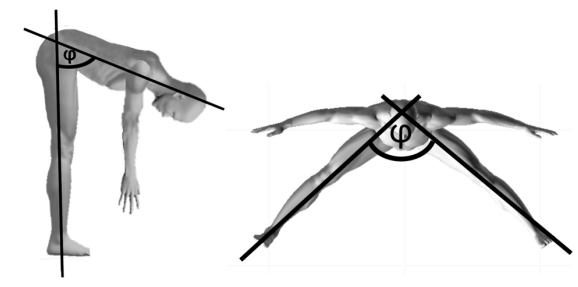
$$M_h = \frac{|F_s| - {}^1\!/_2 F_g \cos \propto}{\cos\ (90 - \propto)}\ l_{leg}$$

Analysis of general and sport-specific adaptions

Experimental Setup

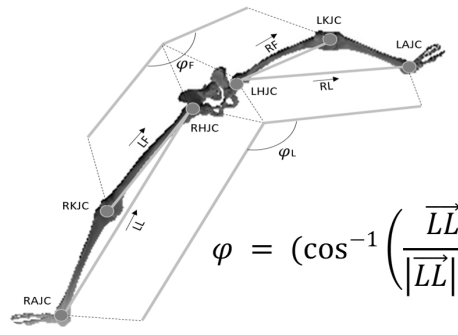


Evaluation methods



Flexion test longitudial plane

Abduction test transverse plane



VSA

$$\varphi = (\cos^{-1}\left(\frac{\overrightarrow{LL}\,.\,\overrightarrow{RL}}{\left|\overrightarrow{LL}\right| \cdot \left|\overrightarrow{RL}\right|}\right))$$

Summary

Methods:
- Double side kick analysis
- In karate and kickboxing
- 44 participants (incl. 10 world or european champions)
- Vicon 3D Motion Capturing
- 4 novel analysis models developed (Balance; Stability; **IA** detection; **VSA**)

Outcomes:
- 12 functional (sub-) phases
- Subtle and short IA better
- 2 PDMS detected, first one more important
- More balance variance in better fighters
- Higher flexibility and ROM in better fighters
- Three journal publications

Implications:
- Fast and high leg elevation is essential
- High hip strength and flexibility required

Acute physiological effects:
- Increased stress tolerance
- Autogenic inhibition
- Reciprocal inhibition

Permanent physiological effects:
- Longitudinal hypertrophy
- Reduced residual tension

Technical requirements:
- Isokinetic mode (constant velocity)
- Hydraulic components
- Ankle rotation safety components
- Foot mounts
- Force measurement
- Solid handles

Outcomes:
- Working prototype for athlete testing
- Novel mathematical models for hip moment calculation
- One patent
- One congress publication

Methods:
- 15 participants
- Vicon 3D Motion Capturing
- Double side kick analysis
- Device training analysis
- Static flexibility analysis

Outcomes:
- High power output during exercise: Ø2.15Nm/kg
- Exceptionally high improvements, in excerpts:
  - Static flexion: +Ø13.56%
  - Static abduction: +Ø10.00%
  - VSA (first kick): +Ø15.15%
- One journal publication

Implications:
- Significant short term strength and flexibility increases
- Highly effective for martial artists to improve kicking pre-requisites.

References

1. Hoelbling, D. (2016): Trainingsgerät. Angemeldet durch Universität Wien. Registration ID: EP16179038.1.
2. Hoelbling, D., Baca, A., & Dabnichki, P. (2020). A Kinematic Model for Assessment of Hip Joint Range-of-Motion in Fast Sport Movements using Spreading Angles. Sports Biomechanics. doi:10.1080/14763141.2020.1795237B
3. Hoelbling, D., Baca, A., & Dabnichki, P. (2020). Sequential Action, Power Generation and Balance Characteristics of a Martial Arts Kick Combination. International Journal of Performance Analysis in Sport. doi:10.1080/24748668.2020.1774730
4. Hoelbling, D., Grafinger, M., Baca, A., & Dabnichki, P. (2020). The Flexibility Trainer: Feasibility Analysis, Prototype- and Test Station development for a Sports Device for Hip-Joint Flexibility and Strength Enhancement. Paper presented at the Proceedings of the 8th International Conference on Sport Sciences Research and Technology Support (icSPORTS 2020), Budapest, Hungary. doi:10.5220/0010019400220029
5. Hoelbling, D., Grafinger, M., Smiech, M., M., Cizmic, D., Baca, A., & Dabnichki, P. (2021). Acute Response on general and sport specific Hip Joint Flexibility to Training with Novel Sport Device. Sports Biomechanics Journal. doi:10.1080/14763141.2021.1922742E
6. Hoelbling, D., Smiech, M., M., Cizmic, D., Baca, A., & Dabnichki, P. (2021). Exploration of Martial Arts Kick Initiation Actions and Telegraphs. International Journal of Performance Analysis in Sport. doi:10.1080/24748668.2021.1920314
7. Hoelbling, D. (2021). The Flexibility Trainer: Biomechanical analysis of martial arts kick performances for user centred product development. (Dissertation), University of Vienna, Vienna, Austria; Royal Melbourne Institute of Technology (RMIT University), Victoria, Australia.