

influence of limited elbow joint range (maximum flexion 120°/140°) and of fixing *humeral rotation* at angles between 20° and 70°.

We observed that the influence of limited *elbow flexion* is much higher than locked *humeral rotation*. Limited *elbow flexion* can e.g. occur when using restraining straps at the biceps brachii or hindering mechanical components like cuffs. The minimum distance between target point and metacarpal bone (end effector) during the unlimited motion was 126.69mm. This distance was taken as optimum. Figures 14-15 show the resulting difference with locked DoF *humeral rotation* (30°) and elbow joint range 0°-140°. Because of the diverging joint ranges already the calculated starting position (results from the inverse kinematics) of the effector is different (Figure 14-15). The optimisation criterion led to a matching position at the median target point (drink bottle) at the end point the distance was +15.9% increased in comparison to the unrestricted motion.

In Table 4 increased displacements in comparison to the unlimited motion and the ratios between unrestricted and restricted motion over all calculations are listed.

Limited joint angle ranges at one joint may lead to compensatory movements at other joints. For a limitation of the elbow joint extensive *shoulder elevation* was seen. The locked *humeral rotation* results in an increased motion in the *shoulder elevation plane*. The evaluation showed that it is most essential to cover the start and end positions, as already proposed in [3]. An end effector based solution seems more realistic for a lightweight and inconspicuous design for braces.

The best fitting solution for our bracing system was a setting with *humeral rotation* locked at 40° and 0°-140° *elbow flexion* range. At least 0°-110° for *shoulder elevation plane* and *shoulder elevation* from 25° to 75° are necessary. Simulations with these joint angle ranges showed similar behaviour as simulations with the unlimited setting, only 5.2% additional displacement was observed for the *drinking* task.

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