

Gait kinematics asymmetry change induced by multijoint hip flexion resistance training – a preliminary research

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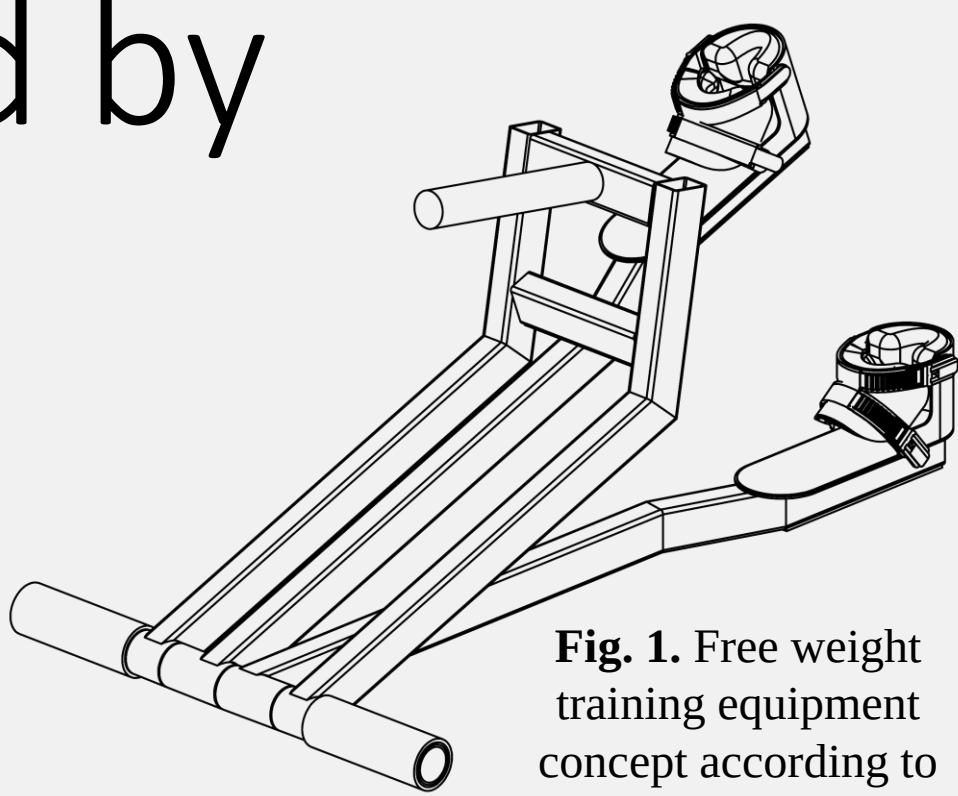


Fig. 1. Free weight training equipment concept according to patent PL 242345 B1

Introduction

The topic of gait symmetry is usually considered when studying amputees or injured patients. However, gait studies of healthy subjects may also bring some value to the understanding of human physiology and biomechanics. It was already found that ground reaction forces present high level of symmetry [1]. Spatio-temporal and kinematic parameters [2] as well as EMG [3] tend to differ laterally. The asymmetry level differ in population and can have several causes but the primal cause lays in the natural process of lateralization that occur in the early ontogenesis [4][5]. Morphological symmetry is usually considered a physical development correctness indicator. Studies also confirm, that increased gait asymmetry correlates with poorer performance in professional runners [6] and higher injury risk in professional athletes [7][8].

Aim

The aim of this preliminary study was to verify the influence of multijoint hip flexion resistance training with the use of a machine according to the patent PL 242345 B1 (Fig. 1) on the gait kinematics symmetry of the lower extremity.

Table 1. Mann-Whitney U-test for differences in asymmetry in gait before and after training intervention

Angle	Before [ang.] (Mean ±SD)	After [ang.] (Mean ±SD)	Difference [ang.]	Mann-Whitney U-statistic	p value
Foot progression sagittal plane	3,09 ± 3,85	3,61 ± 4,33	0,52 *	3103670	< 0,001
Foot progression frontal plane	6,08 ± 3,49	2,89 ± 1,68	-3,19	5197026	< 0,001
Foot progression transversal plane	4,39 ± 3,03	2,39 ± 2,01	-2,00	4708278	< 0,001
Ankle plantarflexion/dorsiflexion	3,43 ± 2,02	2,13 ± 2,09	-1,31	4796053	< 0,001
Ankle inversion/eversion	6,84 ± 1,25	1,37 ± 0,73	-5,48	6720000	< 0,001
Ankle internal/external rotation	29,19 ± 4,36	9,92 ± 3,46	-19,27	6719718	< 0,001
Knee flexion/extension	4,49 ± 3,42	3,08 ± 2,90	-1,42	4346116	< 0,001
Knee abduction/adduction	5,23 ± 6,12	2,64 ± 2,38	-2,59	3805864	< 0,001
Knee internal/external rotation	16,43 ± 3,91	10,78 ± 2,46	-5,65	5996568	< 0,001
Hip flexion/extension	2,18 ± 2,01	2,64 ± 2,79	0,46 *	3036837	< 0,001
Hip abduction/adduction	2,32 ± 1,18	1,77 ± 1,40	-0,55	4354213	< 0,001
Hip internal/external rotation	21,50 ± 5,04	2,96 ± 2,47	-18,53	6710997	< 0,001
Pelvic tilt	1,01 ± 0,85	0,91 ± 0,85	-0,10	3621705	< 0,001
Pelvic obliquity	2,61 ± 1,08	1,51 ± 1,18	-1,10	5175188	< 0,001
Pelvic rotation	4,00 ± 2,66	2,82 ± 2,01	-1,18	4301994	< 0,001

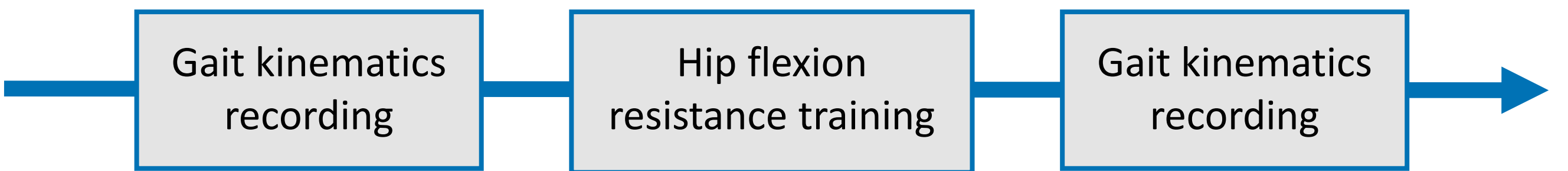
* Asymmetry increase

Materials and methods

The subject of this preliminary study was a healthy woman aged 29, weight 49kg with no severe posture defects. The gait of the subject was recorded with optical motion capture system (Vicon, Oxford Metrics plc, UK) before and after the training intervention.

The exercise of multi-joint resistance hip flexion was applied. Training was conducted with the use of a machine with free weights load and foot bindings attached to the platforms that allows for the application of downward directed force to the foot. Subject was standing on the platforms with her foot fastened in bindings and lifting legs alternately. Each training was preceded with a proper warm-up. Subject performed 120 trainings with the volume of 100 repetitions for each leg, divided into 10 sets of 10 repetitions and 30 sec rest periods. Training was performed every other day with the load equal to 60% 1RM. The load was adjusted to the progress in 1RM that was tested after every 10 sessions and changed gradually from 15 to 25 kg. The patient did not engage in any other regular training for the entire duration of the study.

The joint angles' asymmetry was calculated as an absolute difference between both sides at corresponding times of the interpolated gait cycles. The method was chosen in order to preserve information about angular value of asymmetry for joints angles' comparison.



Results

Almost all joints' angles asymmetries were significantly reduced after the training intervention (Fig. 2). Asymmetry reduction was proportional to mean asymmetry (correlation: $R=-0.88$, $p<0.001$) (Fig. 2). Among all studied angles only hip flex-extension and foot progression in sagittal plane presented asymmetry increase. Angles demonstrating the most asymmetry reduction were ankle inter-external rotation (19.26 deg.) and hip inter-external rotation (18.53 deg.). Both parameters indicate a radical change in right extremity joints ROM. Asymmetry reduction exciding 5 degrees was also observed in ankle in-eversion and knee in-external rotation.

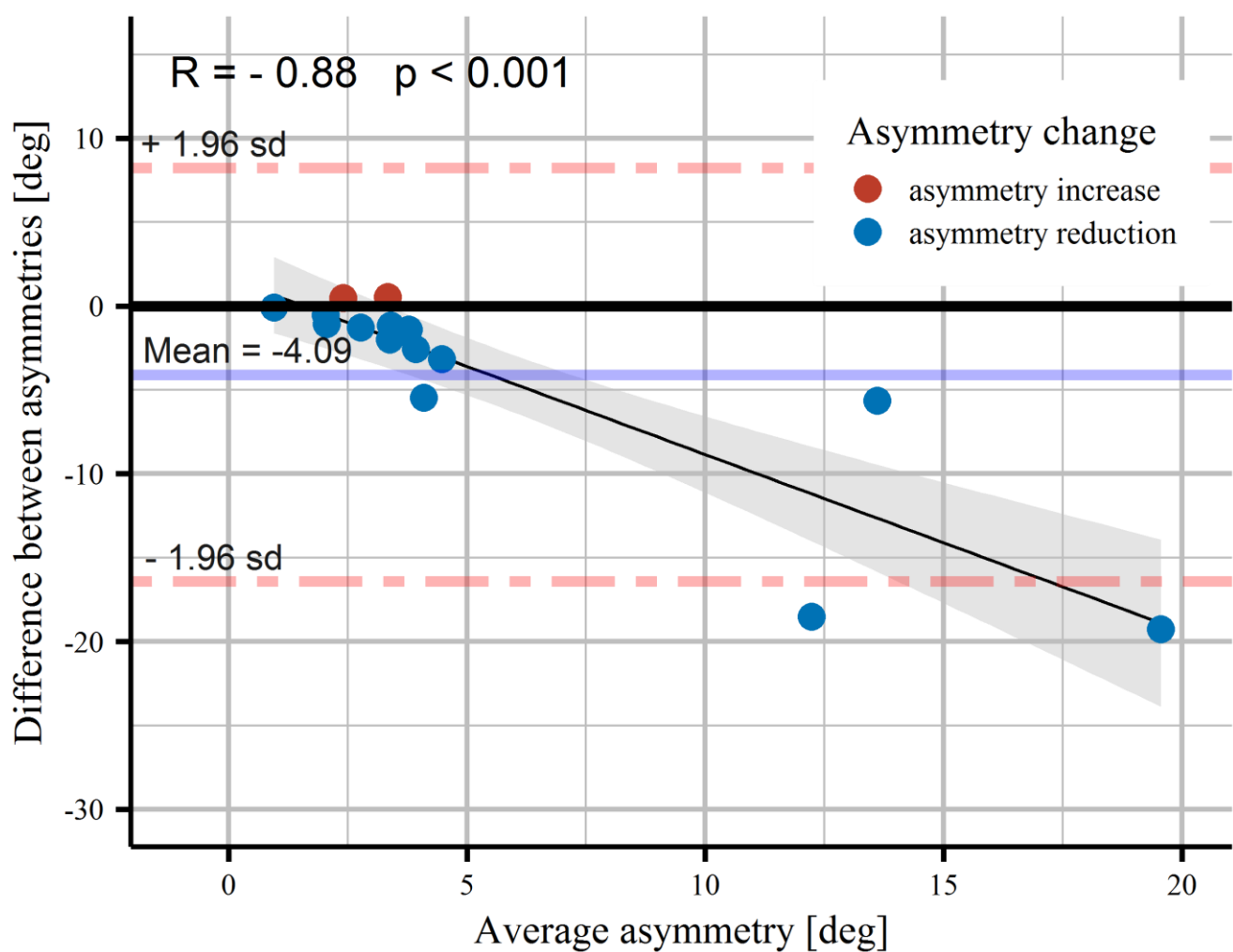


Fig. 2. Bland-Altman plot of difference between asymmetries to average asymmetry before and after training intervention ratio in gait.

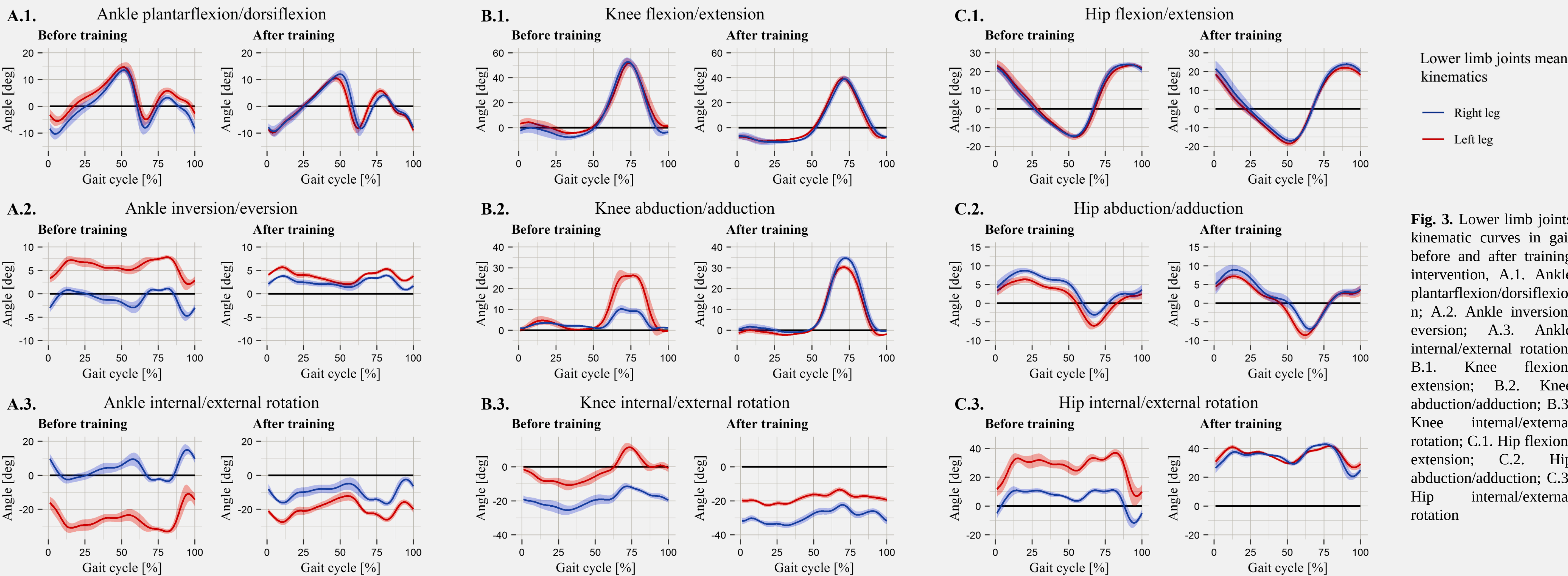


Fig. 3. Lower limb joints kinematic curves in gait before and after training intervention, A.1. Ankle plantarflexion/dorsiflexion; A.2. Ankle inversion/eversion; A.3. Ankle internal/external rotation; B.1. Knee flexion/extension; B.2. Knee abduction/adduction; B.3. Knee internal/external rotation; C.1. Hip flexion/extension; C.2. Hip abduction/adduction; C.3. Hip internal/external rotation

Conclusions

The preliminary study shows that the use of hip flexion resistance training and a machine according to patent PL 242345 B1 has a potential to reduce gait asymmetry in healthy subjects. The exercise is planned to be further validated in a proper study with healthy subjects.

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