Neuromotor Flexibility in Treadmill Walking and Cyclical Punching

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INTRODUCTION

Solution Space (figure 1) is a key concept in a recovery model that explains the emergence of a variety of adaptive changes that may occur in the movement system recovering from an injury (Bosga et al., 2018).

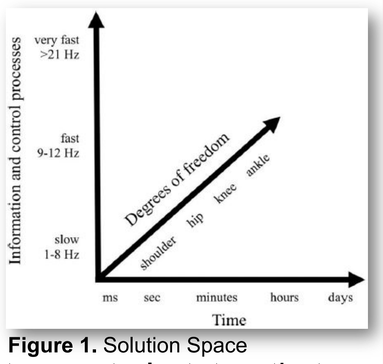

Figure 1. Solution Space

In musculoskeletal disorders compensatory mechanism exist between the injured and non-injured limb (Paterno et al., 2012; Salmon et al., 2005). However, motor equivalence in motor control states that no simple one-to-one correspondence exists between a task and a motor solution. Consequently, movement kinematics of non-injured body segments may reflect overall motor flexibility of the human neuromotor system.

Aim study

Exploring whether neuromotor flexibility in healthy participants is comparable in upper-extremity and lower-extremity tasks.

DESIGN

PARTICIPANTS and MATERIALS

17 healthy subjects (9 males and 8 females; mean age 56 ± 4 years) participated in this study.

Data acquisition and analysis

Angular motions were captured by 6 Xsens wireless sensors (figure 2) and analyzed with SoapSynergy software.

Sensor locations

Sternum, Sacrum, proximal and distal segments of upper and lower extremities.

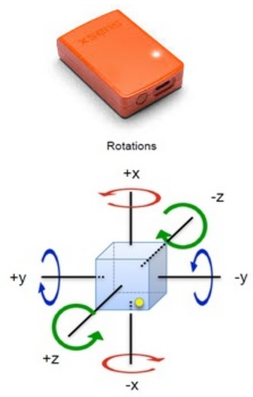

Figure 2. Xsens wireless sensor (top panel) and its 3 dof rotations (bottom panel).

TASK

Participants had to perform a treadmill walking task and a punching task (Figure 3).

Both tasks were performed at three speed conditions:

- comfortable speed
- minus 30% comfortable speed
- plus 30% comfortable speed

Figure 3. Treadmill walking task (left panel) and punching task (right panel).

ANALYSIS

95% CI ELLIPSES

- Neuromotor flexibility was captured by plotting the slope of the power-spectrum density function of the acceleration-time functions in the main movement direction against the sample-entropy of these time functions.
- A larger negative slope and a higher entropy were considered to reflect neuromotor flexibility.
- 95% Confidence Interval (CI) ellipses were created for the 2D representation of the flexibility of the upper and lower-extremity tasks (Figure 4).
- Parameters of the 95% CI ellipses that were analyzed were:
  - Overlap
  - Long axis 95% CI ellipse
  - Area 95% CI ellipse
  - Short axis 95% CI ellipse

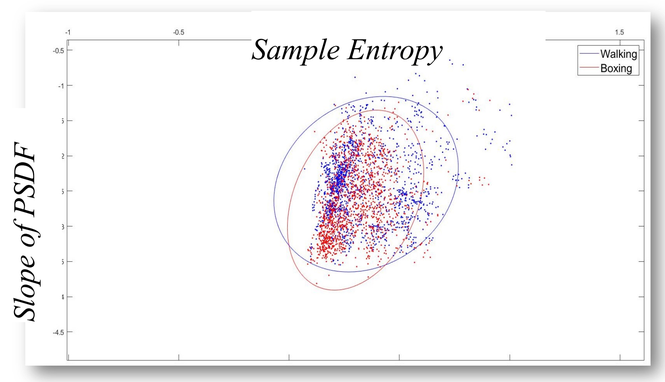

Figure 4. 95% CI ellipses of the treadmill walking task (blue) and punching task (red).

PRELIMINARY RESULTS

SAMPLE ENTROPY AND SLOPE

Both the sample entropy (p =.005) and slope (p = .001) were different between the treadmill walking and punching task (Figure 8 & 9). Walking was more flexible over time, and punching as regards sensorimotor control mechanisms.

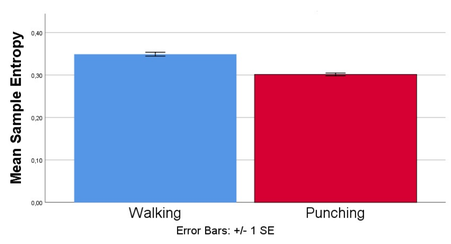

Figure 8. Mean sample entropy.

Figure 9. Mean slope.

95% Confidence Intervals

Overlap and area:

There was no difference between the size of the 95% CI ellipses (p = .191) (Figure 5). *The overlap between the 95% CI ellipses were 85% (blue in red in Fig. 2) and 95% (red in blue in Fig. 2), respectively.*

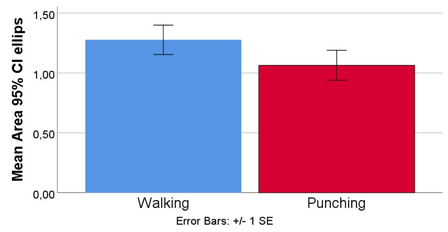

Figure 5. Mean area 95% CI ellipse.

Short and long axes:

Differences in length of both the short (p < .001; Fig. 7) and long axes (p = .016; Fig. 6) of the 95% CI ellipses were found.

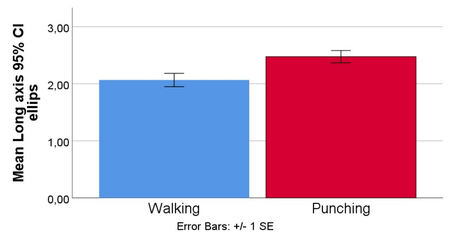

Figure 6. Mean long axis 95% CI ellipse.

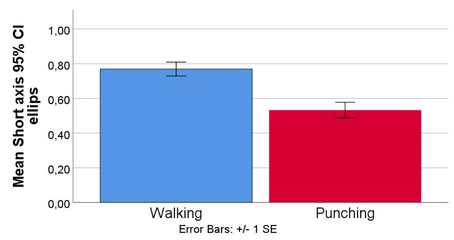

Figure 7. Mean short axis 95% CI ellipse.

CONCLUSIONS

PRELIMINARY RESULTS

The preliminary results seem to indicate that the neuromotor flexibility of punching is comparable to that of treadmill walking in healthy people.

The sample entropy and slope of punching differ from those in treadmill walking. Walking is more flexible in time (SEn) while punching is more flexible in sensorimotor control (slope).

An index of neuromotor flexibility of upper-extremity tasks might serve as baseline for lower-extremity tasks.

FUTURE STUDIES

Future studies will focus on:

- The implications of a musculoskeletal disorder for the neuromotor flexibility of injured and non-injured body segments.
- The effects of recovery from a musculoskeletal disorder on the neuromotor flexibility of injured and non-injured body segments.

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