

# Activities of Daily Living in Healthy Adults and Children

## Reliability of Registrations with Multiple Body Worn Sensors

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### 1 OBJECTIVES

Patients with stroke or cerebral palsy often encounter arm-hand problems during daily life. Assessment is important to determine the progress of arm-hand performance in patients during rehabilitation, and to ascertain the effectiveness of therapies. Many instruments are available to assess capacity or perceived performance, but instruments assessing actual performance are scarce (Lemmens et al., 2012). Inertial sensors may be used to assess actual performance. However, signal reliability during execution of activities of daily living (ADL) should be determined first.

Aim of this study was to examine the reliability of the data of upper extremity skill performance in a standardized setting, in both healthy adults and healthy children, registered using a combination of multiple body worn sensors.

### 2 METHODS

In this non-randomised cross-sectional study, both healthy adults (aged > 50 years) and healthy children were included. Because motor control processes may mature with age, resulting in differences in skill execution, the children were divided into two age groups, i.e. 6-11 years and 12-18 years. Four 9-DOF sensor devices, each containing a tri-axial accelerometer, gyroscope and magnetometer were attached to the dominant hand, wrist, upper arm and chest of participants.

Data were registered during the execution of 5 repetitions of 2 tasks, i.e. 'drinking from a cup' and 'eating with knife and fork'. Tasks were first performed without extensive instructions (e.g. with the instruction: "drink from the cup."), and subsequently with extensive instructions on how to perform the task (e.g. "reach to the cup, grasp it,

bring it to your mouth, take a sip, put the cup back on the table and go back to your starting position.").

Signals were filtered with a 4<sup>th</sup> order zero-time lag low-pass Butterworth filter (cut off frequency of 1.28 Hz). Repetitions of each specific task were identified and intra-class correlation coefficients (ICC) for each sensor and signal type were determined as a measure of reliability, both within and between subjects. For every person, a mean ICC was measured. Since data was not normally distributed, medians were calculated. The ICCs were classified based on the kappa statistic classification of Landis and Koch, i.e. ICC between 0.8-1.0=very good; 0.6-0.8=good; 0.4-0.6=moderate; 0.2-0.4=fair; <0.2=slight (Landis and Koch, 1977).

### 3 RESULTS

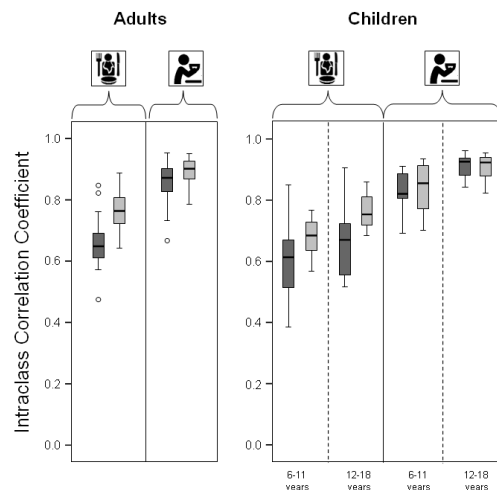


Figure 1: Within-subject reliability expressed as intra-class correlation coefficients, for the skills eating and drinking. Dark grey bars represent the performance of the task without instruction, whereas light grey bars represent the performance of the task with instruction.

Thirty adults were included (14 women, 16 men, mean age  $58.0 \pm 5.1$  years), 16 children aged between 6-11 years (9 girls, 7 boys, mean age  $8.5 \pm 1.7$  year) and 16 children aged between 12 and 18 years (8 girls, 8 boys, mean age  $14.6 \pm 1.5$  years).

Figure 1 displays within-subject reliability of the skills drinking and eating for both the adults and the children. With regard to the within subject reliability, the median ICC's were good for the skill eating and very good for the skill drinking. Reliability was better for the skill performed with instruction compared to the skill performed without instruction, especially for the skill eating. Furthermore it can be seen that the children aged between 12-18 years showed a slightly higher reliability compared to the children aged between 6-12 years.

Figure 2 displays between-subject reliability of the skills drinking and eating for both the adults and the children.

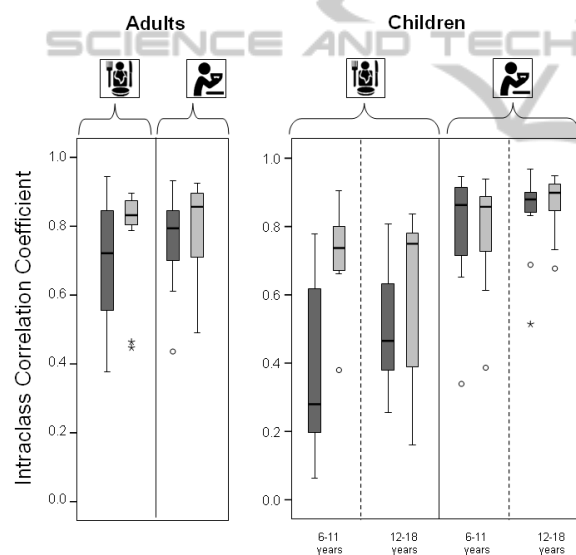


Figure 2: Between-subject reliability expressed as intraclass correlation coefficients, for the skills eating and drinking. Dark grey bars represent the performance of the task without instruction, whereas light grey bars represent the performance of the task with instruction.

Between-subject reliability was good to very good for both skills performed by adults. The skills drinking performed by the children had a very good reliability whereas the skill eating had a fair to moderate reliability in the youngest children, and a good reliability in the older children. Especially for the skill eating, a big difference was seen regarding the reliability of the performance without instruction compared to the performance with instruction. For the skill drinking, reliability was comparable

between younger children and the older children whereas for the skill eating, performance of the older children had a higher reliability.

## 4 DISCUSSION

Overall, the skill drinking as well as the skill eating had a good to very good within-subject reliability in both adults and children. Performance with instruction had a higher reliability compared to performance without instruction. By giving instructions about how to perform the task, the variability in execution of the task was reduced, thereby increasing the reliability.

The performance of the skill drinking had a higher reliability compared to the skill eating. This can be explained by the complexity of the skills, i.e. drinking is a rather simple skill, which cannot be performed in many ways, whereas the skill eating consists of more sub movements and can, in addition, be performed in many different ways.

Between-subject reliability of the skill eating was relatively low, especially for the performance without instruction in the youngest children. This can be explained by the fact that many children did not use the knife to cut the food, whereas other children had difficulties manipulating the knife. For the performance with instruction, they were told how to use the knife.

In conclusion, we have shown that a combination of multiple body worn sensors is able to reliably register activities of daily living in healthy adults as well as in healthy children. Future research will focus on the investigation of signal reliability during activities of daily living performed by patients and in a daily life setting.

## REFERENCES

- Landis, J. R. and Koch, G. G. (1977) The measurement of observer agreement for categorical data. *Biometrics*, 33, 159-74.
- Lemmens, R., Timmermans, A., Janssen-Potten, Y., Smeets, R. and Seelen, H. (2012) Valid and reliable instruments for arm-hand assessment at ICF activity level in persons with hemiplegia: a systematic review. *BMC Neurology*, 12, 21.