Technical Quality Assurance For Strength Measurements Performed With Hand Held Dynamometer

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Introduction

Hand Held Dynamometers (HHD) are widely used in the clinical practice to assess muscle strength. HHD is inexpensive, easy to use and does not require specific patient preparation.

The therapist simply applies the instrument, asks the patient to exert his maximum force and then reads the force value on the display of the device.

HHD measures are affected by inaccuracies due to the operator and patient positioning. Studies about the inter-tester reliability were already conducted and it was concluded that the method is questionable due to the low reproducibility among trial repetitions [1], and due to the experience of the clinician [2].

The aims of this work are to test quality and reliability of strength measurements and to assess the interval of uncertainties, due to positioning of the HHD.

Materials and Methods

Measures were conducted in the Motion Analysis and Robotics Laboratory at Ospedale Pediatrico Bambino Gesù, (Vicon MX, Oxford, UK, motion capture system).

A MicroFet dynamometer (Hoggan Scientific, UT) was equipped with four passive markers as shown in Fig. 1. The central marker was removed in the dynamic trials to allow application of the HHD and its position was reconstructed through the three fixed markers. The subject was equipped with the Plug-In-Gait marker protocol and additional markers on the knees and clusters on the thighs (Fig. 2).

The Vicon system allowed to reconstruct the relative position of the HDD and allowed to compute the direction, orientation and application axis of the measured force.

Knee flex/ext trials were acquired with the subject sitting on a bench and the operator holding the HHD (Fig. 6). The HHD was placed at 5 cm from the ankle.

The subjects were requested to push against the HHD with as much force as they could (≈5 s). The therapist had to push back in order to keep the shank still [1].

Two operators (1 expert, 1 not expert), 6 subjects, 5 repetitions were acquired so far.

Figure 1. Dynamometer with the four markers.

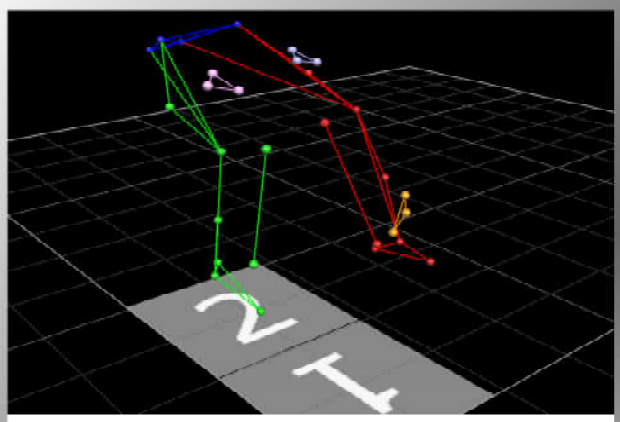

Figure 2: Full marker protocol used for this study and example of trial recording for a left knee extension trial. Markers in yellow represents the HHD position.

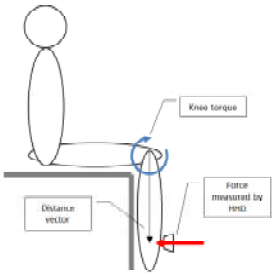

Figure 3: Definition of knee force and torque.

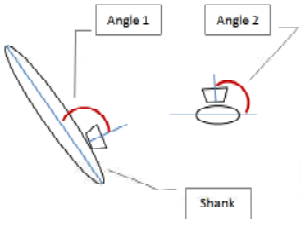

Figure 4: Definition of HHD angles. On the left: lateral view, on the right: coronal view.

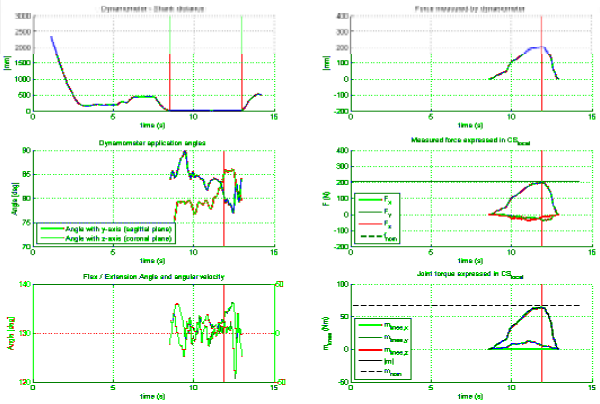

Figure 5: Full marker protocol used for this study and example of trial recording for a left knee extension trial.

	OP	Sex	Age	Mispositioning (mm)	CV	Knee RoM [°]	CV	Angle 1 [°]	CV	Angle 2 [°]	CV
Subj 1	1	F	29	7	0,89	11	0,66	89	0,06	79	0,09
Subj 2	2	M	26	55	0,29	29	0,34	81	0,08	57	0,25
Subj 3	1	M	30	-7	2,47	23	0,23	98	0,03	82	0,06
Subj 4	2	F	26	27	0,12	31	0,41	88	0,01	54	0,09
Subj 5	1	F	26	4	3,27	16	0,50	81	0,06	87	0,04
Subj 6	1	M	28	-17	0,72	36	0,10	91	0,02	89	0,08

Operator		
	1	Experienced
	2	Unexperienced

Table 1: Kinematics results – knee extension – average values over 5 repetitions.

	OP	Sex	Age	Max Force [N]	CV	Nominal Moment [Nm]	Moment Z [Nm]	Moment X [Nm]	Moment Y [Nm]	Paired t-test Nominal vs Z
Subj 1	1	F	29	170	0,13	55	52	10	0	0,0037
Subj 2	2	M	26	264	0,20	87	57	40	0	0,0024
Subj 3	1	M	30	234	0,07	74	73	10	0	0,4335
Subj 4	2	F	26	194	0,12	52	37	27	0	0,0109
Subj 5	1	F	26	219	0,07	71	70	3	0	0,3605
Subj 6	1	M	28	289	0,13	72	80	1	0	0,0006

Operator		
	1	Experienced
	2	Unexperienced

Table 2: Kinetics results – knee extension – average values over 5 repetitions.

Figure 6: Trial acquisition.

Following parameters were recorded:

- Maximum force
- Nominal knee moment (nominal shank length)
- 3D Knee moment (measured distance knee-dynamometer, Fig. 3)
- Knee RoM
- Angles between the dynamometer and the shank (Fig. 4)
- HHD misplacement (distance between dynamometer and ankle)

Knee moment was computed along the three anatomical axes: flex/ext, ab/add and intra/extra rotation. The knee RoM was measured to ensure the knee maintained the requested position during the trial.

Discussion and Conclusion

This work represents a preliminary study on data quality of HHD measurements. Sample results for 1 subject, 1 trial are shown in Fig. 5. Detailed results are shown through Tables 1 and 2.

- Moment components on undesired directions are generally low (last graph in Fig. 5).
- Knee RoM was generally low but was never 0 or negative (Table 1). The operators were unable to fully counteract patient's force.
- Unexperienced operator achieved worst results in dynamometer positioning: Angle 2 in Table 1.
- Low Coefficient of Variation (CV) for maximum force (Table 1) suggests high intra operator repeatability.
- Coherently with kinematics analysis, unexperienced operator obtained a z moment lower than experienced, with respect to nominal moment (Table 2).
- Misplacement of HHD leads to higher x-component of the moment.

In most cases the moment in the principal direction was compatible with the respective nominal value. Other components were lower.

Experience of the operator is a crucial requirement for high-quality measurements.

Further data acquisition is necessary. Collecting more data from experienced and unexperienced operators will allow to define threshold values for "good" and "bad" trials.

Advanced statistics should be performed to assess repeatability and inter – intra operator reliability.

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References

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