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Letter to the Editor

Response to letter to editor regarding: Assessment of range and quality of neck movement using a smartphone-based application

We appreciate the insightful comments provided in this letter to editor regarding our Technical and Measurement note: Assessment of range and quality of neck movement using a smartphone-based application. We hope that the following response will reduce the concerns raised in the letter.

We do acknowledge that range of motion can be measured accurately using many different methods. For such purposes, the Cervical Range of Motion tool (CROM) has often been used in previous studies. However, we refer to 3D motion capture analysis as gold standard for measuring movement in our study as, to our knowledge, no other assessment method is superior with regards to measuring the variables we were interested in i.e. range and quality of motion. In our manuscript (see: *Signal processing),* quality of motion (QOM) was defined "… *as the variance of the angular jerk between start and end of the movement*". Referring to it as a relevant "criterion" or "reference standard" instead of gold-standard would therefore, in our view be stating the same, just in different words.

We agree that we investigated concurrent validity, which is a subset of criterion-related validity. Considering that we explicitly stated that measurements were conducted simultaneously with both systems (abstract, methods (under "*Assessment of range of motion*") and discussion (under "*Methodologic considerations and limitations*") we assumed that it would be implicit for the reader that we were assessing concurrent validity but not predictive or postdictive validity (the other subsets of criterion validity). We regret to see that this did not translate properly in the text.

The technical specifications of the camera system were not described in detail although we did refer to the camera system in the text (*Assessment of range of motion*). The camera system comes on a tripod and has three cameras embedded in it. Active markers are used to communicate with the camera system. The camera system was placed in an oblique angle to the subject (see: *Assessment of range of motion*). The smartphone used in this study (*iPhone 6*) has sensors, which allow the user to measure e.g. speed and angles. Several applications are available freely online which provide a user interface that convert these signals to meaningful values e.g. m/s, degrees. For the purpose of collecting data in this study however, Medei designed a specific application (*Balancy*) which allowed us to collect data at a specified sampling frequency of 50Hz; identical to the sampling frequency used in the camera system (see: *Assessment of range of motion*). This software is not commercially/freely available for smartphone users. The application does not need any calibration. Data from both systems were aligned using a normalization procedure which is described in the manuscript the under the section "*signal processing*".

This manuscript was submitted as a Technical and Measurement note and accepted as such for publication after the peer-review process. From a clinical perspective, evaluating movements in all planes would have been interesting. However, as the purpose of the study was to compare the measurement accuracy of the smartphone with the 3D camera system but not the clinical utility of the device, we did not consider this necessary. Further, due to the reciprocal movement coupling that occurs (see discussion in *Methodologic considerations and limitations*) it was assumed that adding side bending of the neck would not provide additional information.

We acknowledge that it may confuse the reader when stating that we expected there to be good-to-excellent agreement between the two systems, as the term "agreement" would pertain the levels of agreement determined by the Bland-Altman plot. For determining the criterion validity in this study (concurrent validity), the Pearson Correlation coefficient is an appropriate method to use (Morrow et al., 2015). All P-values (for Bland-Altman plots and correlation analyses) are presented in table 2. As explicitly stated in the table legend, all p-values are Bonferroni corrected. In Fig. 4, the dotted lines represent the upper- and lower limits of agreement and indicate ± 1.96 SD of the mean. We regret that this caused confusion.

As rightfully pointed out in the letter to editor, Quek et al. (2014) calculated the ICC's and the Spearman rank correlation coefficient to determine the concurrent validity (instead of the Pearson's correlation coefficient). The difference in the statistical approach (Spearman Vs Pearson's) is probably related to differences in how data were distributed in these studies. As stated in our manuscript (Results: first paragraph), data were normally distributed (for QOM after log-transformation) and therefore we considered it relevant to calculate the Pearson's correlation coefficient. It is the Speaman rank correlation coefficient we are referring to in our manuscript when we compare findings to Quek et al. We did not use a CROM device as Quek et al. did. However, unlike Quek et al. concluded, we do not believe that our results were affected by electromagnetic interference as our study was conducted in a laboratory fitted with a Faraday cage (not mentioned in the manuscript).

We did not consider it valuable to determine the reliability in this study (test-retest, intra-tester or inter-tester) for reasons we specified in the manuscript (see: *Methodologic considerations and limitations*). It is to be expected that a healthy person would demonstrate fluctuations in movement patterns, which would probably be manifested in between-session differences in the variables assessed in this study (range and jerkiness). Measuring the participants on two occasions (or more) would probably have confirmed this but would not have helped us determining whether the data from the two devices (smartphone and 3D camera) captured the same variables (range and variance of angular jerk). We have no reason to believe that natural fluctuations would occur in the way signals were recorded in the two devices (given that the sampling frequency was kept unchanged) or in the way Matlab processed these data. Lastly, considering the nature of this manuscript (Technical and Measurement Note), it is outside the scope of the paper to comment on the clinical utility of the methods investigated here. Any

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such conclusion can only be made after testing the technology in a clinical population. This was explicitly stated in the manuscript (see: *Methodologic considerations and limitations)*.

It is correct that, according to the Danish rules and regulations, studies where two measurement methods are compared do not require a formal approval from an ethical committee. Nevertheless, we maintain an ethical code of conduct here at our university, regardless of whether a formal approval is given/needed or not. This includes providing thorough and appropriate information to the participants and attaining their informed consent in writing prior to entering the study. Even though studies like these do not require a formal approval, it is stated in the Helsinki declaration (World Medical Association, 2013) that "*… the research protocol must be submitted for consideration, comment, guidance and approval to the concerned research ethics committee before the study begins*". Therefore, our protocol was submitted for consideration and guidance on whether the study needed an approval from the regional ethics committee. In general, the protocol is screened by members from the ethical committee (a lawyer and the chairman of the committee) who then determine whether the study needs formal approval by the ethical committee. The result from this screening process was that it this protocol did not need to be evaluated by the full committee and could be conducted without further approval. This is what we state in the manuscript.

Conflict of interest declaration

None to report.

Ethical approval

The protocol adhered to the guidelines of the regional ethical committee. These state that studies such as this one where two methods are compared do not require an ethical approval.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.msksp.2019.04.013.

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