Author’s response to reviews

Title: Validation of a novel Kinect-based device for 3D scanning of the foot plantar surface in weight-bearing

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Author’s response to reviews:

The authors would like to thank both reviewers for spending their time revising the manuscript. We hope the reviewers will appreciate that the authors have done their best to address all of the reviewers’ advices and believe the manuscript has greatly improved by addressing these comments.

All the major modifications have been highlighted in yellow in the text.

A point-by-point answer to the reviewers’ comments follows.

Reviewer #1:

Page 2, Line 34:

The word 'dealt' seems inappropriate here, at least in the Australian use of English. I wonder if the word 'managed' may be a more appropriate word as it evokes a more clinical focus.

We agree with the reviewer’s suggestion, and have changed “dealt” with “managed”.

Page 2, Line 44 and 46:

This sentence has low readability, recommend:
The aim of this study was to design and validate a novel 3D foot scanner based on the Microsoft Kinect sensor, allowing a 3D scan of the plantar shape of the foot to be acquired in weight-bearing.

As suggested by the reviewer, we have modified the sentence to improve readability.

Page 2, Line 56:
Insert a 'The' at the start of the sentence to improve readability.
'The' accuracy and repeatability…..
Ok, thanks for the suggestion.

Page 3, Line 3:
I would argue that there is not an increasing interest in personalised orthotic devices, as custom made devices have been made for decades (if not longer). I suspect your message here is that there is an increasing interest in using 3D scanning and additive manufacturing to make orthotic devices. The reference that you have used discusses this change in fabrication technique. This sentence state this more clearly.

Yes, the reviewer’s point is correct. Therefore, we have now revised the sentence according to his recommendation.

Page 3, Line 50:
The correct terminology in this context would be 'orthoses' rather than 'orthotics'.
'…..is critical to designing custom orthoses and footwear….'
Thanks for the remark, we replaced all “orthotics” instances with “orthoses”.

Page 3, Line 53:
Terminology: 'sportsmen' is gendered language and should only be used if referring male athletes only. Recommend a change to 'athletes':
'….. and athletes (4), to patients……'
Ok, we agree with the reviewer on the too-gender specific terminology employed here. We therefore have changed “sportsmen” with “athletes”.

Page 3, Line 55:
Terminology: 'diabetic patients' defines the person by their illness. 'patients with diabetes' is better language. Recommend:
'… such as patients with diabetes (6,7).' 
Ok, it has been revised according to the reviewer’s comment.

Page 3, Line 58:
Delete 'foot' to improve readability.
'The medial longitudinal arch, the foot most notable…….'
Ok, the word “foot” has been removed to improve readability.

Page 4, Line 5:
Correct terminology here would be 'orthoses' rather than 'orthotics'.
Thanks again, we have double checked all “orthotics” instances in the text and modified accordingly.

Page 4, Lines 10-14:
I have a few issues with this sentence and paragraph. I think this section needs to be re-written. Obviously, you have chosen to use a full-weightbearing scan in your study, you need to very clearly explain why you chose to do that. The justification is currently not clear.

A few points to consider:
Although Tsung et al did find the non-weightbearing cast reduced plantar pressures, the peak pressure was reduced the most by the semi-weightbearing cast. Would this have been a better casting position to use in your study?

Thanks for the comment. We regret the loading conditions used in this investigation were not clearly specified throughout the manuscript. Semi weight-bearing (that we defined as bipedal standing posture) was used to acquire the subjects’ feet, as shown in Figure 1. In order to better clarify the loading condition, we added “... – or semi-weight bearing - ...” in the Methods. In fact, we have generally described the present scanning device as capable to scan subjects’ feet in weight-bearing – regardless of the type of loading applied either semi or full weight-bearing or any other amount of loading applied to the feet. Still, the validation of the Kinect as scanner device was here performed with the feet in semi weight-bearing, but any other loading condition could have been used to assess the accuracy. The semi weight-bearing was preferred over other weight-bearing postures for it is highly repeatable, as better explained in the revised manuscript.

We totally agree with the reviewer on that comfort was not evaluated in Tsung et al. therefore any reference related to comfort has been now removed in the revised manuscript.

Page 4, Lines 15-19:

Do you have a reference to support this statement? Anecdotally I would suggest that plaster casts very rarely model the foot in weightbearing (at least in Australian clinical practice).

We agree with the reviewer on that plaster casting does not model the foot in weight-bearing, as other casting methods do (i.e. foam boxes). Therefore, we have modified the sentence by deleting the reference to the plaster casting technique.

In our understanding, “casting methods”, do comprise plaster casting, casting socks, foam boxes etc. But we are happy to modify further erroneous definitions if the reviewer believes so.

Page 4, Lines 20-27:

A definitive statement such as this should have a reference. Has the difference between foam boxes and 3D scans been investigated? (In Australia it is very common for clinicians to take a foam boxes and scan it using a sensor scanner. This is done to capture a semi-weightbearing posture (primarily based on the work of Tsung et al (2004) and Guldemond (2206))

We do agree with the reviewer on that this sentence was wrongly formulated and may imply that foam boxes are less accurate than 3D scanners. In fact, 3D laser scanners are often used in combination with foam boxes, as correctly pointed out by the reviewer. Here, the authors wanted to highlight the different boundary conditions the foot is subjected to when taking a foot
impression in a foam box. In order to address the reviewer’s comment, this sentence has now been removed from the manuscript and the previous sentence has been revised by adding two references to support the better inter-rater reliability of digital scanning technology compared to traditional casting methods.

Page 4, Lines 39-44:

The final sentence of this paragraph starts with 'Therefore', implying a link with the previous sentence, however the previous sentence does not refer to traditional casting methods.

This sentence is also incorrect, although plaster is not often used to capture a full-weightbearing posture, it can used for this purpose.

Following the reviewer’s advice, this sentence has been removed and the statement “..and do not provide automatic foot measurements” has been moved to the sentence revised also in the previous comment.

Page 4, Line 56 - Page Line 2:

This sentence is very long with poor readability. Consider a re-write to clarify the key purpose of the sentence.

We agree with the reviewer on that this sentence had poor readability. The sentence has been re-written and divided into two parts, in order to clarify the key purpose.

Page 6, Line 14:

The Foot Posture Index does not use the terminology: flat, rectus, and cavus, instead it uses the terminology 'pronate' 'normal' and 'supinated'. Considering your reference is Redmond et al (2008), I would recommend using their terminology.

We would like to thank the reviewer for the remark.

It is indeed correct that Redmond et al. (2006) have used the terms "pronated" " normal" and "supinated" to classify the postural differences according to the scores established for the FPI. It has however been largely shown that "pronation" is associated to flat- or low-arched feet and that "supination" is associated to cavus or high-arched feet (Redmond et al., 2008; Burns et al., 2005).
In fact, in our investigation, both podoscopic evaluation and FPI scores were used to analyse the foot type of each subject and the two evaluation methods were mostly in agreement.

However, we should highlight that the division between flat (or low-arched) and cavus (or high-arched) feet was mainly performed using the podoscopic evaluation according to the rather large experience of our group on foot types and foot biomechanics.

Feet showing reduced midfoot contact area in weight-bearing were here classified as "cavus", whereas those showing larger midfoot contact areas were here classified as "flat". The appropriateness of this podoscopic-based classification was confirmed a posteriori by the outcome of the automatic measurements of the main morphological parameters, as the largest arch-index values were observed for flat feet and the smallest for the cavus feet (see table 3).

Since the purpose of the present investigation was focused on the validation of the Kinect sensor as plantar foot scanner, and not on the morphological differences between foot types, we may consider it acceptable to use the "flat" and "cavus" definitions to differentiate the feet of our population according to the midfoot contact area.

We hope the reviewer will appreciate that this point has now been better clarified in the Methods.

Page 7, Line 18-20:

See note above regarding common terminology (pronated, normal, supinated) in the published literature.

'Exemplary' is often interpreted as mean 'perfect' and 'flawless'. I wonder if 'sample' may be a more appropriate word here.

Please see the answer to the previous comment regarding the terminology. According to the reviewer’s comment, we replaced the word “exemplary” with the expression “sample”.

Page 7, Line 25 - 30:

'Arch depth' is not a measurement I have seen before. Based on your description I wonder of 'Arch width' is a more accurate description? I'm happy for this comment to be ignored.

We appreciate this comment. The authors could not find any previous reference to this measure in the literature. In light of the reviewer’s observation, we have realized that the expression “arch width” defines more clearly the measurement we refer to. We replaced therefore all the “arch depth” with “arch width” throughout the manuscript. Thank you.
Page 7, Line 58:

Insert 'an' into this line:

'…resulted in an inter-subject average…..'

Ok.

Page 8, Line 47:

Readability will be improved by inserting 'all':

'….was observed across all trials.'

Ok, thanks for the suggestion.

Page 9, Line 53-55:

See note above regarding common terminology (pronated, normal, supinated) in the published literature.

See note above.

Page 10, Line 37:

This sentence refers back to the Background section where you state an issue with current scanners is that they don't allow weightbearing scans. I think it is important that you clearly state why this is an issue. Most clinicians don't want to take full-weightbearing scans, so your justification here needs to be very clear.

We hope this matter has now been better clarified in a comment above. In this manuscript, “weight-bearing” has been used as general term as opposite to neutral posture or non weight-bearing, and not as synonymous of full weight-bearing. Following this revision, it should be more clear that in this study the feet were scanned in semi weight-bearing. Nevertheless, as highlighted above, it was not the scope of this investigation to scan the foot to obtain custom orthoses. The Kinect setup assessed here for reliability and accuracy allows to scan the foot in different weight-bearing conditions - as well as in unloaded/neutral posture -, and for different purposes therefore we believe this feature should be properly highlighted as an advantage with respect to other digital scanning methods.
Page 11, Line 32:
Insert 'a' into the sentence to improve readability:
'…applications of such a device…'
This sentence has been removed to address a comment of the other reviewer.

Page 12, Line 22:
Readability issues. Switch the words 'allow' and 'also'.
'This should also allow…..'
Text has been rephrased according to the reviewer’s comment.

Page 13, Line 5:
Terminology here should be 'orthoses' rather than 'orthotics'.
Ok, see note above.

Page 13, Line 7:
Suggest deleting the word 'preliminary'.
The word “preliminary” has been deleted as requested by the reviewer.

Reviewer #2:
Page 3
Line 57
The medial longitudinal arch of the foot is the most notable morphological feature used to characterize the foot type (8, 9), allows the foot to act like a spring We have modified the text also following a similar advice from the other reviewer (“foot” has been deleted).
Forces act to deform the foot joints spanning the medial longitudinal arch and the soft tissues.

Forces act to deform the foot joints and soft tissues spanning the medial longitudinal arch. - Suggestion!

Thanks for the suggestion, the sentence has been rephrased accordingly.

Line 10
You highlight improved comfort and pressure reduction of non-weight bearing casted orthoses but why would a weightbearing cast be preferable?

If a particular foot position is contributing to the symptoms of a subject/patient, why support them in that position?

The reference to the improved comfort (Tsung et al., 2004) has been removed from the revised manuscript.

The authors would like to specify that in this manuscript “weight-bearing” has been used as general term as opposite to neutral posture or non weight-bearing, and not as synonymous of full weight-bearing. However, semi weight-bearing, the condition employed for foot scanning in the present investigation, is associated to the largest peak pressure reduction (Tsung et al., 2004). We have generally described the present scanning device as capable to scan subjects’ feet in weight-bearing – regardless of the type of loading applied either semi or full weight-bearing or any other amount of loading applied to the feet.

In fact, it was not the scope of this investigation to scan the foot to obtain custom orthoses. The validation of the Kinect as scanner device was here performed with the feet in semi weight-bearing, but any other loading condition could have been used to assess the accuracy of the setup.

Line 19
weightbearing

and require modification by podiatrists with extensive experience in the field.

The whole sentence has now been removed, also following the other reviewer’s comments.
Line 22
Casting allows to obtain a foot impression and can also be applied in weight-bearing (suggestion - use undertaken rather than applied)

The whole sentence has now been removed following the other reviewer’s comments.

Line 24
You state foot models are less accurate than those obtained by 3D scanning can you please justify this!

This sentence has now been removed following also a similar comment by the other reviewer.

Line 46
Although 3D scans are significantly cost-effective compared to the consumable costs of plaster casts (16, 17), -

We have modified the sentence as suggested, thanks for the advice.

Page 5
Line 26
Kinect sensor has been largely exploited also outside the gaming industry
- Suggestion - Kinetic sensor has also been employed outside the gaming industry

Thanks for the comment. The sentence has been revised according to the reviewer’s suggestion.

Page 6
Line 36
Please define user-specified tolerance

The sentence has now been revised to explain better how the alignment algorithm works as follows:
“The alignment was achieved via the “Best Fit Alignment” procedure: a preliminary gross alignment is performed by matching 5000 random points, and finer adjustments can be obtained by using 25000 random points, until the average deviation between scans is minimized”

The user specified tolerance is chosen according to the expected degree of accuracy of the alignment and affects the computational time. This value (here set at 0.1 mm) should be lower than the expected error in the final alignment and was chosen to decrease the computational time by allowing the best matching between surfaces.

Page 9
Line 43
were largely similar to the corresponding PodoBox
Thanks for the comment, “largely” has been deleted.

Line 51
Arch Index and arch depth values were consistent with the clinical classification. The
Suggestion - classification; the….. (Use semi colon to maintain the flow of the sentence)
Thanks for the suggestion. The sentence has been modified accordingly.

Page 11
Line 27
The inter-subject average RMSE in the 3D
shape of the medial arch was about 1.5 mm,
Need to discuss how 1.5mm error statistically may be irrelevant but clinically could make a device unusable you need to discuss this point rather than "appears to be appropriate"

The sentence has now been revised to better clarify how the outcome of this analysis should be interpreted.

Page 12
This study has shown that the accuracy of the Kinect sensor, within the setup specifically designed for this investigation, appears sufficient to obtain 3D scans of the foot plantar surface in weight-bearing, suitable for different clinical and biomechanical applications.

Appears sufficient - this statement needs rewording and in respect to what (maybe compares well to the gold standard scanner?? Or similar to this)

We thank again the reviewer for these sensible comments. Our purpose was to compare the accuracy of the Kinect-based foot scanner with the current gold standard – i.e. the laser scanners. The sentence has now been revised to take into account this answer to the reviewer.