Author's response to reviews

Title: Reliability of the TekScan MatScan(R) system for the measurement of postural stability in older people with rheumatoid arthritis

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Author's response to reviews: see over
Response to reviewers

Reliability of the TekScan MatScan® system for the measurement of postural stability in older people with rheumatoid arthritis

Response to reviewer’s report

Anna Hatton

Thank you for your comments and suggestions for the improvement of the manuscript. To follow are our responses.

Comment 1:

Abstract:

In the methods section, please clarify that double-limb quiet standing was assessed. Please add this detail throughout the manuscript.

Response:

The phrase “double-limb quiet standing” replaces “quiet standing” in abstract and throughout manuscript.

Comment 2:

Background:

Pg 3. para 1: The first paragraph contains good definitions of postural stability and postural sway. However, it would be nice to see some text clarifying what we understand by the phrases ‘base of support’ (e.g. defined by the outer boarders of the feet etc.) and ‘active neural control’ [of the COM position in space].

Response:

The phrase “base of support” and “active neural control” has been clarified in the text.

In order to maintain postural stability the body’s global centre-of-mass (COM) must remain inside the body’s base of support; as defined by the outer borders of the feet. This requires active neural control, whereby the central nervous system maintains the COM position in space, resulting in tiny oscillatory movements referred to as postural sway.

Comment 3:

Methods:

Pg 5, para 1: Equipment – I would question whether Figure 1 is necessary. If the authors believe Figure 1 enhances their manuscript, I would suggest they improve the format of the figure (i.e. editing of individuals graphs in a separate document, rather than presenting a screen shot). This
Response to reviewers

Figure is also misleading as it presents postural sway data over a duration of 19.95 seconds - when in the current study, postural control is reported to be collected over 30 seconds.

Response:

Figure 1 has been deleted. Figures 2-5 renamed to 1-4.

Comment 4:

Pg 6, para 2: Procedure – Between-session reliability of the TekScan® system was assessed on two separate occasions approximately one hour apart. The authors should justify why this time frame was selected. From a clinical perspective, testing sessions 24hr or 1-week apart would be more relevant; however, it is understandable that longer time frames would also be likely to succumb to larger error due to potential changes in the inflammatory disease condition etc., and this was not the aim of the study. I suggest the authors justify their chosen methodology.

Response:

Sentence added to justify one hour interval between testing sessions.

A one hour interval was chosen for practical purposes to enable data collection to occur during the participant’s scheduled podiatry appointment. The one hour interval also ensured that the clinical characteristics of the participants remained consistent.

Comment 5:

Pg 6, para 2: Please can the authors clarify instructions given to participants, during the 1hr waiting period between testing sessions (e.g. were they allowed to walk around the University [which could have led to fatigue], remained seated in a room, permitted to have refreshments?). How did the authors control this aspect of the test procedures?

Response:

Sentence added to clarify instructions to participants during 1 hour interval between testing sessions.

During the period between sessions, participants were provided with a podiatry assessment and treatment as required. To avoid fatigue, the podiatry appointment was conducted in an adjoining room.

Comment 6:

Pg 6, para 2: Trials were repeated three times with eyes open (EO) and eyes closed (EC) to obtain a mean value. Were the visual conditions block-randomized – further clarification is required.
Response to reviewers

Response:

No randomisation of eye condition occurred. Sentence added to clarify in text.

*Participants were tested with eyes open (EO) then eyes closed (EC). Trials were repeated three times for each eye condition to obtain a mean value.*

Comment 7:

Pg 6, para 2: The authors state that ‘Each participant was asked to step off the pressure mat and rest for 30 seconds between repetitions to avoid fatigue’. What happened during the 30 seconds rest period – did participants remain standing or were they seated?

Response:

Participants sat between trials (30 seconds). The word “rest” changed to “sit” to clarify.

*Each participant was asked to step backwards off the pressure mat and sit for 30 seconds between repetitions to avoid fatigue.*

Comment 8:

Data Analysis:

Pg 7, para 1: I suggest the authors provide more detail relating to how the TekScan data was processed. Were the full 30 seconds of sway data analysed?

Response:

Postural control data was collected and analysed over 30 seconds.

Comment 9:

Pg 7, para 1: Please clarify methods for obtaining the estimated true scores

Response:

Thank you for the comment. From the literature we know that errors of measurement are composed of both random error and systematic error. It represents the discrepancies between scores obtained on tests and the corresponding true scores. However, we believe using a range of statistical tests in the current study that the reader will have sufficient information from the current results.

Comment 10:

Pg 7, para 1: Treatment of outliers in the data – included or excluded in the analysis?
Response to reviewers

Response:

There were no outliers. Statement added to Results section.

No outliers were identified.

Comment 11:

Results:

Pg 8, para 1: Could the authors please report whether all participants completed the trials. Any corrupt or missing data?

Response:

Yes all participants completed the trials. Sentence added to clarify.

All participants completed the trials.

Comment 12:

Discussion:

P9, para 3: The authors suggest that measurement error may have occurred as a result of inherent variability of postural control parameters within their study sample. I suggest that the authors review this text within the context of their study aim – to assess between-session reliability over 1hr. Please add a little more detail, perhaps relating to specific demographics and clinical characteristics that could lead to such measurement error.

Response:

SEM, SEM% and SRD further explored in relation to the source of measurement error, the context of the study and the clinical worth of the parameters. Section revised as below:

Measurement error can be due to the precision of the instrument, systematic error introduced by the rater, or the variation in the population being measured [33]. In the current study, measurement error may have occurred as a result of the inherent variability of postural control parameters in the study sample. The wide range in recorded sway values, resulting in a large SD of the mean, supports this possibility. Variation in postural stability parameters within an RA population is to be expected and may be associated with the differing demographic and clinical characteristics of the sample. For example, in a study of 61 patients with RA, Ekdahl [11] found that age, sex and high C-reactive protein level were related to decreased postural control in quiet standing. Given the relatively broad inclusion criteria in the current study, it would be expected that this population would display a broad range of demographic and clinical characteristics and therefore a potentially wide range of postural sway values. Therefore, in the current study, the relatively high SEM, SEM% and SRD values may be indicative of the variability of the population tested rather than the reliability of the equipment used to test the population.
Response to reviewers

It can be further argued that SEM and SRD values are of more relevance in the analysis of within-subject variability. Indeed in a clinical setting measures of postural stability would be undertaken on individuals not populations and the ability to detect a real change in the variables measured over time is essential. As the study aim was to assess between-session reliability over 1 hour, within-subject variability was not analysed however it is acknowledged that such analysis would be valuable in determining the potential measurement error of the system in a clinical setting.

Comment 13:
Pg 10, para 1: I suggest the authors delete the text ‘and during gait’ from the second sentence of this paragraph, to keep the text closely aligned to their study aims relating to standing balance.

Response:
The text “and during gait” deleted.

Afferent input from the somatosensory, visual and vestibular systems combine with coordinated muscle activity to maintain balance in quiet standing.

Comment 14:
Pg 10, para 1: The authors state that ‘In healthy adults, postural control is maintained through flexibly and smoothly changing between these systems in order to maintain stable equilibrium’. The phrase ‘flexibly and smoothly changing’ may be misleading, suggesting that different sources of afferent input and muscle activity are used independently of each other, one at a time, in order to maintain balance, when in fact, they may be used in combination. I suggest the authors review this wording.

Response:
The phrase “flexibly and smoothly changing...” changed to aid clarity.

In healthy adults, postural control is maintained through flexible and smooth interaction between these systems in order to maintain a stable equilibrium.

Comment 15:
Pg 10, para 2: The authors state that ‘In the current study, the mean of three test measurements of 30 seconds was taken to stabilise the variable’. Again, the term ‘stabilise’ is misleading in the context of the study – please review.

Response:
The last part of the sentence “to stabilise the variable” removed.

In the current study, the mean of three test measurements of 30 seconds was taken.
Response to reviewers

Comment 16:
Pg 10, para 3 – Pg 11, para 1: The authors highlight the importance of vision for postural control. In agreement with previous research, the current study found greater AP and ML sway with eyes closed relative to eyes open. The authors should consider the importance of this text within the context of their study: more clarity is required. It may be advantageous for the authors to provide evidence that postural sway data collected in the current study is of a similar magnitude, and comparable, to that reported in previous research in people with RA, with eyes open and/or eyes closed.

Response:
The importance of eyes open and eyes closed test conditions has been further highlighted in the text as follows:

Further, when assessing AP and ML sway in an RA population compared with healthy controls, Rome et al. [15] found that, while both groups demonstrated greater sway in eye closed conditions compared to eyes open, the effect was more marked in the RA group. It is important therefore that postural stability in an RA population is assessed with eyes open and eyes closed and hence eyes open and eyes closed test conditions were used to assess the reliability of the equipment in the current study.

Whilst we could compare the sway data with previous studies this would not be relevant to the aims of the current study which are to assess the reliability of the equipment not the sway parameters of the population of interest.

Comment 17:
Pg 11, para 2: I suggest the authors are more specific in summarising their study findings, stating their population: ‘The results of the current study suggest that researchers and clinicians can confidently use the TekScan MatScan® to assess postural control in quiet standing in older adults with RA’.

Response:
Statement amended.

The results of the current study suggest that the TekScan MatScan® is reliable for assessing postural control in double-limb quiet standing in older adults with RA.

Comment 18:
Pg 11, para 3: The authors may like to consider other areas for future research including: assessment of the reliability of the TekScan MatScan® during more complex, dynamic balance tests in people with RA.
Response to reviewers

Response:

Future directions amended.

The reliability of the TekScan MatScan® for assessing double-limb quiet standing in healthy adults would be useful. Future investigations should also explore the reliability of the system during more complex dynamic balance tests, in people with RA, as well as other populations of interest such as patients with diabetes or older adults with a history of falls. Testing of the reliability of postural control measures in participants’ usual footwear will also be of interest.

Comment 19:

Figures:

Please add units of measurement to the Figures/Figure legends.

Response:

(mm) added to Figure legends.
Response to reviewers

Reliability of the TekScan MatScan® system for the measurement of postural stability in older people with rheumatoid arthritis

Response to reviewer’s report

Sarah Curran

Thank you for your comments and suggestions for the improvement of the manuscript. To follow are our responses.

Comment 1:
Abstract:
In the background section the authors mention ‘…compared to healthy controls…’ and this may confuse readers in thinking that normal data would be collected and reiterated to further correlated with existing data. The authors should perhaps reword this sentence for absolute clarity.

Response:
The term “healthy controls” replaced with “non-RA populations” to avoid misleading the reader into thinking that data would be collected from a control group in the current study.

*People with rheumatoid arthritis (RA) have decreased postural stability compared to non-RA populations and impaired postural stability is associated with falls in people with RA.*

Comment 2:
Abstract:
In the methods section, the authors need to state the mean age and standard deviation of the RA sample investigated. It would also be useful if the authors state the speed of recordings (40Hz).

Response:
Mean age and standard deviation added in abstract methods section.

*Twenty three participants with RA, mean (SD) age 69.74 (10.1) years, were assessed in barefoot double-limb quiet standing, with eyes open and eyes closed, for antero-posterior and medio-lateral postural sway values.*

Speed of recordings added (40 Hz).

*Three repetitions, at a sampling frequency of 40Hz, were recorded for each test condition to obtain a mean value.*
Response to reviewers

Comment 3:

Abstract:

For the conclusion a further sentence should be added and the existing last sentence should be observed with caution given the wide range of the individuals – this is why the mean and standard deviation should be added to methods section. The range was fairly large at 60 – 80 as stated in your main methods section on page 10 (last paragraph, 2nd line from bottom).

Response:

Abstract conclusion rewritten to include a further sentence and clarify the age range of the sample tested.

The portability and ease of use of the TekScan MatScan® makes it a useful tool for the measurement of postural stability in clinical and research settings. The TekScan MatScan® system can reliably measure double-limb quiet standing in older people, aged 60 to 80 years, with RA.

Comment 4:

Background:

The background section provides the relevant information. On page 4 the authors statement regarding moderate to good reliability of the Tekscan MatScan is too descriptive and I would expect further details in terms intraclass correlation coefficients/SEM figures. I realise the present authors have used the Fleiss guidelines, but not every reader/author uses this classification system, and moderate to good figures can differ.

Response:

Further details of ICCs added for the two reliability studies referenced with explanation of moderate to good reliability given.

The TekScan MatScan® is commonly used in research and clinical settings and has previously been shown to have moderate to good reliability for the measurement of plantar forces and pressures during barefoot walking in healthy children (ICCs 0.58 to 0.99) [17] and adults (ICCs 0.44 to 0.95) [18]. In both studies, interpretation of the ICCs was in accordance with Portney and Watkins [19] whereby values of > 0.75 indicate good reliability, values ranging from 0.5 to 0.75 imply moderate reliability and values < 0.5 suggest poor reliability.
Response to reviewers

Comment 5:

Background:

If no reports exist on the reliability of the Tekscan MatScan has not been undertaken in normals – why weren’t they examined in this study – why were only RA individuals explored? I realise this study is focussed to RA, but reliability data on normal / healthy individuals would be useful.

Response:

Only individuals with RA were explored in the current study as the authors intend to use the TekScan MatScan in a larger study exploring postural stability in people with RA specifically. However the authors agree that reliability data on normal / healthy individuals would be useful and this statement has been added at the end of the discussion.

The reliability of the TekScan MatScan® for assessing double-limb quiet standing in healthy adults would be useful.

Comment 6:

Methods:

Page 5 – the paragraph on clinical characteristics could be better presented -it is all in one sentence and reads like a list! Can the authors amend? For the procedure – relevant information is provided and the inclusion of a template for foot position is key to enhancing standardisation and reliability of the measures obtained.

Response:

It is the authors’ intention to list the clinical characteristics measured however the section has been amended to read better.

Clinical characteristics including age, ethnicity, gender, body mass index (BMI), disease duration, co-morbidities, revised Health Assessment Questionnaire (HAQ-II) [21] and pharmacological management, were recorded for each participant. Pharmaceuticals included non-steroidal anti-inflammatory drugs (NSAIDs), methotrexate, other disease modifying anti-rheumatic drugs (DMARDs), prednisone and biologic therapies.

Comment 7:

Methods:

Was the step off the mat forward or backwards?

Response:

The step off the matt was backwards. The word “backwards” has been added for clarity.
Response to reviewers

Comment 8:
Methods:
Data analysis – relevant information provided. It is good to see the inclusion of the Bland-Altman plots.
Response:
Thank you for the comment. No amendment required.

Comment 9:
Results:
Relevant findings reports and supported with tables and figures. Table 1 – add ranges to the demographic and clinical characteristics.
Response:
Ranges added to Age, Disease Duration, BMI and HAQ score in Table 1.

Comment 10:
Discussion
The discussion picks up on relevant points. The ICCs appear to be good, but the SEM, SEM% and SRD were fairly high. Whilst this is acknowledged by the authors and reasons for measurement error are explored further discussion on the ICCs, SEM, SEM% and SRD should be explored with the latter three parameters having more clinical worth since they represent absolute values rather than the relative values of the ICCs.
Response:
SEM, SEM% and SRD further explored in relation to the source of measurement error, the context of the study and the clinical worth of the parameters. Section revised as below:

Measurement error can be due to the precision of the instrument, systematic error introduced by the rater, or the variation in the population being measured [33]. In the current study, measurement error may have occurred as a result of the inherent variability of postural control parameters in the study sample. The wide range in recorded sway values, resulting in a large SD of the mean, supports this possibility. Variation in postural stability parameters within an RA population is to be expected and may be associated with the differing demographic and clinical characteristics of the sample. For example, in a study of 61 patients with RA, Ekdahl [11] found that age, sex and high C-reactive protein level were related to decreased postural control in quiet standing. Given the relatively broad inclusion criteria in the current study, it would be expected that this population would display a broad range of demographic and clinical characteristics and therefore a potentially wide range of postural sway values. Therefore, in the current study, the relatively high SEM, SEM% and SRD values may be
indicative of the variability of the population tested rather than the reliability of the equipment used to test the population.

It can be further argued that SEM and SRD values are of more relevance in the analysis of within-subject variability. Indeed in a clinical setting measures of postural stability would be undertaken on individuals not populations and the ability to detect a real change in the variables measured over time is essential. As the study aim was to assess between-session reliability over 1 hour, within-subject variability was not analysed however it is acknowledged that such analysis would be valuable in determining the potential measurement error of the system in a clinical setting.

Comment 11:

On page 11, the authors mention that the consistency of the data gathered echoes that of previous studies -Zammitt et al. and Cousins et al., but these studies focussed on barefoot walking rather than postural sway. One study findings cannot give absolute confidence – reliability should always be viewed as a continuum. The findings are very interesting, but there is a gap which remains and lack of comparison for normal data, and to a certain extent there is and was an expectation of direct links to such literature (seen as it is yet to be reported) or normative (case matched ideally) in this study. Whilst this does not omit the paper from being accepted from publication it warrants discussion by the authors.

Response:

We agree that comparison with dynamic studies is not useful. We are stating that the TekScan MatScan has been shown to be reliable in previous studies. We agree, however, that the findings from one study cannot give absolute confidence in the reliability of the equipment and we have amended this sentence as follows:

“The results of the current study suggest that researchers and clinicians can confidently use the TekScan MatScan® to assess postural control in quiet standing.” Amended to read:

The results of the current study suggest that the TekScan MatScan® is reliable for assessing postural control in double-limb quiet standing in older adults with RA.

As the focus of the current study is the reliability of the equipment and not the postural sway characteristics of the participants per se, comparison with normative data is unnecessary. However we agree that reliability data on normal / healthy individuals would be useful and this statement has been added at the end of the discussion as per comment 5 above.

Comment 12:

The authors collected data in the first session and then one hour later for a second session. This only represents day variability, and the authors need to provide a rationalisation as to why this was done. Why not measure one week apart? Is there a learned response from the subjects and would fatigue play a part? I doubt it given the amount of repetitions, but it must be acknowledged. I do however acknowledge the complexity of RA patients and from one week to the next, there situation may change which in turn could have a negative impact on the findings.
Response to reviewers

Response:

Sentence added to justify one hour interval between testing sessions.

A one hour interval was chosen for practical purposes to enable data collection to occur during the participant’s scheduled podiatry appointment. The one hour interval also ensured that the clinical characteristics of the participants remained consistent.

Comment 13:

In terms of the number of repetitions of postural sway measurements and in order to improve the SEM, SEM% and SRD – were three repetitions enough? Keijzers et al. (2009) reported that 3.8 steps were required to obtain an ICC of 0.85. Although this is related to dynamic assessment rather than static this observation for the ICC does correlated well with the findings presented here (table 3), apart from the ML sway EO (ICC at 0.84). As further assessment should the authors consider increasing the repetitions to enhance reliability? The full reference of the Keijzers et al. (2009) is provided below. Keijzers NLW, Stolwijk NM, Nienhuis B, Duysens J. (2009) A new method to normalize plantar pressure measurements for foot size and foot progression angle. Journal of Biomechanics 42: 87-90.

Response:

Thank you for the reference but this is a dynamic study and the purpose of this study was to develop and test a simple method that normalizes the plantar pressure pattern for foot size, foot progression angle, and total plantar pressure in 12 asymptomatic subjects. The authors strongly argue that three repetitions were sufficient and that increasing the repetitions may introduce fatigue in our RA cohort. We have justified this methodology referencing a study in a population with chronic arthritis.

Comment 14:

Was recording at 40Hz quick enough? It should be, but again this needs to be highlighted by the authors.

Response:

We are limited by the manufacturers. We believe 40Hz is acceptable to record the postural sway parameters of interest. We accept there are more robust systems based in gait laboratories such force plates and balance measuring systems, but the current equipment is portable and easy to use in a clinical setting and this counteracts the low sampling rate. However, we accept the sampling rate is low and have reported this as a limitation.

A sampling frequency of 40Hz is relatively low, compared to laboratory based force plate technology, however we believe it is acceptable for measuring the postural sway parameters of interest.
Response to reviewers

Comment 15:

Conclusion:
The authors explore the role of future investigations in the conclusion section – this does not really belong here and it should be stated within the main discussion section (albeit towards the end of this section). The authors should address this imbalance and amend accordingly.

Response:

Discussion and Conclusion sections amended accordingly.

(Last paragraph of Discussion)

The reliability of the TekScan MatScan® for assessing double-limb quiet standing in healthy adults would be useful. Future investigations should also explore the reliability of the system during more complex dynamic balance tests, in people with RA, as well as other populations of interest such as patients with diabetes or older adults with a history of falls. Testing of the reliability of postural control measures in participants’ usual footwear will also be of interest.

Conclusion

The portability and ease of use of the TekScan MatScan® makes it a useful tool for use in research and clinical practice. The results of the current study demonstrated good to excellent between-session reliability of postural control measures in older people with RA using the TekScan MatScan® pressure mat.