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Upper body and ankle strategies compensate for reduced lateral stability at very slow walking speeds

Aaron N. Best and Amy R. Wu

Article citation details
Proc. R. Soc. B **287**: 20201685.
http://dx.doi.org/10.1098/rspb.2020.1685

Review timeline

Original submission:	13 July 2020
Revised submission:	1 September 2020
Final acceptance:	22 September 2020

Note: Reports are unedited and appear as submitted by the referee. The review history appears in chronological order.

Review History

RSPB-2020-1685.R0 (Original submission)

Review form: Reviewer 1

Recommendation
Major revision is needed (please make suggestions in comments)

Scientific importance: Is the manuscript an original and important contribution to its field?
Good

General interest: Is the paper of sufficient general interest?
Good

Quality of the paper: Is the overall quality of the paper suitable?
Acceptable

Is the length of the paper justified?
Yes

Should the paper be seen by a specialist statistical reviewer?
No

Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.
No

It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.

Is it accessible?
Yes

Is it clear?
Yes

Is it adequate?
Yes

Do you have any ethical concerns with this paper?
No

Comments to the Author
This manuscript describes a secondary analysis of a previously published dataset, investigating speed-dependent changes in various metrics with the potential to provide insight into the control of lateral stability during human walking. I think the results are interesting, but also believe that the manuscript would benefit from the addition of further detail to the Methods and clarification of several of the presented results.

Major comments
1. Why did the analyses of mediolateral hip and ankle torques focus on their values at the time of minimum MoS? It would seem that these torques could be just as important for braking/accelerating the CoM in the mediolateral direction at all other time points in the gait cycle. I think that it is particularly important to justify this decision, as it appears to have a major impact on the results. Based on Figure 4, it looks as though choosing to quantify the peak torques rather than the torques at minimum MoS would produce exactly the opposite results. This makes it hard for me to think that the final sentence in the first Discussion paragraph is fully justified (which seems to argue for the preferential importance of the ankle and hip strategies at slower speeds).

2. To help readers, I think the organization of the Results could be improved, as they seem to jump around a bit. It took me a few times reading through this section before I was confident I was understanding the results correctly. Specifically, presenting the results in a consistent order would be helpful. Currently, the first paragraph of the Results refers to changes in MoS, then XCoM, then trunk CoM excursion, and so on. But the rest of the Results starts with trunk CoM excursion, before later jumping back to XCoM and then MoS results.

3. Also, presenting the results with a consistent structure would be helpful. In some cases, the results are presented as dimensionless variables, while in other cases they are not. For example, the first full paragraph on page 5 states that average minimum MoS decreased linearly at 0.02 m/ms-1. But the corresponding table appears to state that this metric changed with a slope of 0.07 (dimensionless). Also in some cases, the rate of change of various metrics with altered walking speed are presented in numerical values (as above), while in other cases they are presented as a proportion of the rate of change of other metrics (e.g. “1.4 times greater than the rate at which the CoP moved laterally”). It would be simpler for readers if the structure of the presented results was consistent.

4. I am having a hard time making sense of the combined results presented in Figures 2 and 3. I would expect that the minimum margin of stability (presented in Figure 2) would be equal to the difference between the CoP position and XCoM position at the time of the minimum margin of stability (both presented in Figure 3). But this doesn't appear to be the case. The difference between these values in Figure 3 appears to be approximately constant across gait speeds – around ~0.03. But in Figure 2, the MoS varies widely – from below 0.01 to over 0.03. Am I misinterpreting these figures?

Minor comments

1. In the second full paragraph on page 3, I suggest more explicitly stating whether the referenced "decrease in stability" and "increase in stability" accompany an increase or decreased walking speed.

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5. While acknowledged in the Discussion, I think it would be beneficial to explicitly state in the Methods that metric values for the two legs were averaged together, and to justify this decision.

6. In Figure 2, what are the shaded colored areas around each line?

7. In the first paragraph of the Discussion, I think this should be "amplitude of the trunk CoM displacement…".

8. The first paragraph of the Discussion states that step width remains unchanged, but I don't think this result was actually presented here.

9. Figure 3 refers to the "average lateral position" of several metrics. This is the average position relative to what? I would imagine that some sort of correction would at least need to be made to account for combining the left and right legs.

Review form: Reviewer 2 (Sjoerd Bruijn)

Recommendation
Major revision is needed (please make suggestions in comments)

Scientific importance: Is the manuscript an original and important contribution to its field?
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General interest: Is the paper of sufficient general interest?
Good

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Acceptable

Is the length of the paper justified?
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Should the paper be seen by a specialist statistical reviewer?
No

Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.
No

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Is it accessible?
Yes

Is it clear?
Yes

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Do you have any ethical concerns with this paper?
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Comments to the Author
Review: RSPB-2020-1685
Title: Upper body and ankle strategies compensate for reduced lateral stability at very slow walking speeds

This manuscript describes a study undertaken to assess the effects of really slow walking on maintaining gait stability. Subjects were measured at several very slow walking speeds, and MoS, and related variables were calculated. MoS decreased with decreasing walking speed, which was cause by increased trunk velocities, with constant step width. Furthermore, at minimum MoS ankle eversion torque and hip abduction torque increased with decreasing speed (but for hip, see below), which the authors take to suggest that the contributions of both the ankle and the upper body to stability are more crucial than stepping at slow speeds. Overall, this is a nice manuscript describing a simple experiment which provides novel insights into the mechanisms of remaining stable gait at slow speeds. Such studies are important as elderly (who fall most often) often walk at such slow speeds. However, I do have some suggestions for further improvement.

Major

Methods
Page 4: “Specifically, the trunk and CoP positions were used to evaluate the contribution of the upper and lower body to the change in the MoS.”; With respect to what were these positions calculated? Was this simply with respect to the lab reference frame, or with respect to the stance leg (CoP?)?. This also holds for figure 1b and 3. If these positions are in lab coordinates, how did

the authors cope with potential drift on the treadmill which could affect outcomes then?

Results
Page 4 :" the ankle eversion torque and hip abduction torque also grew in magnitude as gait speed slowed." While this is true for the ankle eversion torque, at minimum MOS it doesn't seem to be true for the hip abduction torque, at any point, or peak ankle eversion torque (cf figure 4, lower panels?)
Also, later, the authors seem to realise this, page 5: "Similarly, the hip torques were similar among the different gait speed conditions but with reduced peak magnitudes as well (Figure 4A bottom)". All in all, it seems that the description of the data is not in line with the data presented. Even within figure 4 (lower panels), we seem to see a decrease in hip abduction moment magnitude at minimum MoS with decreasing speed, yet lower panel b indicates an opposite relationship. How is this possible? Needless to say, this has influences for the discussion as well.

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figure 2a is not clear, as not all lines can be seen. Also, it appears that the XCoM is outside of the COP for quite some time. Does this have to do with using a combined COP from two forceplates? What if single forceplate COP would be used? Either way, it would be good to have the figures somewhat larger so that they can be read.

Decision letter (RSPB-2020-1685.R0)

13-Aug-2020

Dear Mr Best:

Your manuscript has now been peer reviewed and the reviews have been assessed by an Associate Editor. The reviewers' comments (not including confidential comments to the Editor) and the comments from the Associate Editor are included at the end of this email for your reference. As you will see, the reviewers and the Editors have raised some concerns with your manuscript and we would like to invite you to revise your manuscript to address them.

We do not allow multiple rounds of revision so we urge you to make every effort to fully address all of the comments at this stage. If deemed necessary by the Associate Editor, your manuscript will be sent back to one or more of the original reviewers for assessment. If the original reviewers are not available we may invite new reviewers. Please note that we cannot guarantee eventual acceptance of your manuscript at this stage.

To submit your revision please log into http://mc.manuscriptcentral.com/prsb and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions", click on "Create a Revision". Your manuscript number has been appended to denote a revision.

When submitting your revision please upload a file under "Response to Referees" - in the "File Upload" section. This should document, point by point, how you have responded to the

reviewers' and Editors' comments, and the adjustments you have made to the manuscript. We require a copy of the manuscript with revisions made since the previous version marked as 'tracked changes' to be included in the 'response to referees' document.

Your main manuscript should be submitted as a text file (doc, txt, rtf or tex), not a PDF. Your figures should be submitted as separate files and not included within the main manuscript file.

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If your study contains research on humans please ensure that you detail in the methods section whether you obtained ethical approval from your local research ethics committee and gained informed consent to participate from each of the participants.

Use of animals and field studies:
If your study uses animals please include details in the methods section of any approval and licences given to carry out the study and include full details of how animal welfare standards were ensured. Field studies should be conducted in accordance with local legislation; please include details of the appropriate permission and licences that you obtained to carry out the field work.

Data accessibility and data citation:
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In order to ensure effective and robust dissemination and appropriate credit to authors the dataset(s) used should also be fully cited and listed in the references.

If you wish to submit your data to Dryad (http://datadryad.org/) and have not already done so you can submit your data via this link
http://datadryad.org/submit?journalID=RSPB&manu=(Document not available), which will take you to your unique entry in the Dryad repository.

If you have already submitted your data to dryad you can make any necessary revisions to your dataset by following the above link.

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Electronic supplementary material:
All supplementary materials accompanying an accepted article will be treated as in their final form. They will be published alongside the paper on the journal website and posted on the online figshare repository. Files on figshare will be made available approximately one week before the accompanying article so that the supplementary material can be attributed a unique DOI. Please try to submit all supplementary material as a single file.

Online supplementary material will also carry the title and description provided during submission, so please ensure these are accurate and informative. Note that the Royal Society will not edit or typeset supplementary material and it will be hosted as provided. Please ensure that

the supplementary material includes the paper details (authors, title, journal name, article DOI). Your article DOI will be 10.1098/rspb.[paper ID in form xxxx.xxxx e.g. 10.1098/rspb.2016.0049].

Please submit a copy of your revised paper within three weeks. If we do not hear from you within this time your manuscript will be rejected. If you are unable to meet this deadline please let us know as soon as possible, as we may be able to grant a short extension.

Thank you for submitting your manuscript to Proceedings B; we look forward to receiving your revision. If you have any questions at all, please do not hesitate to get in touch.

Best wishes,
Dr Locke Rowe
mailto: proceedingsb@royalsociety.org

Associate Editor
Comments to Author:
The reviewers indicate that major revisions are needed to improve the quality of your paper before it would be suitable for publication. R1 notes several methodological concerns that need to be clarified, as well as improving how your results are organized and reported. R1 also notes concerns about the results reported in Figs 2 & 3, which they find somewhat inconsistent and difficult to interpret.

R2 also raises a key methods issue concerning what the kinematics frame of reference is in your analysis of CoM and CoP positions is for determining values of margins of stability (MoS). Finally, R2 also notes a major concern for results reported on p. 4 & 5, with respect to Fig. 4.

Hopefully, you can address these major concerns, as well as the other minor points that are raised.

Reviewer(s)' Comments to Author:
Referee: 1

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Referee: 2

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Author's Response to Decision Letter for (RSPB-2020-1685.R0)

See Appendix A.

Decision letter (RSPB-2020-1685.R1)

22-Sep-2020

Dear Mr Best

I am pleased to inform you that your manuscript entitled "Upper body and ankle strategies compensate for reduced lateral stability at very slow walking speeds" has been accepted for publication in Proceedings B.

You can expect to receive a proof of your article from our Production office in due course, please check your spam filter if you do not receive it. PLEASE NOTE: you will be given the exact page length of your paper which may be different from the estimation from Editorial and you may be asked to reduce your paper if it goes over the 10 page limit.

If you are likely to be away from e-mail contact please let us know. Due to rapid publication and an extremely tight schedule, if comments are not received, we may publish the paper as it stands.

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All supplementary materials accompanying an accepted article will be treated as in their final form. They will be published alongside the paper on the journal website and posted on the online figshare repository. Files on figshare will be made available approximately one week before the accompanying article so that the supplementary material can be attributed a unique DOI.

Thank you for your fine contribution. On behalf of the Editors of the Proceedings B, we look forward to your continued contributions to the Journal.

Sincerely,
Dr Locke Rowe
Editor, Proceedings B

mailto: proceedingsb@royalsociety.org

Associate Editor:
Comments to Author:
Dear Authors,

Thank you for clarifying your methods and addressing well the reviewers' critical comments. I believe that your paper now makes a novel contribution by examining walking stability at the very low speeds, which have not been examined before.

Appendix A

Response to Reviewer Comments:

We would like to thank the reviewers and editor for their feedback on the manuscript. The comments provided were very constructive and will help improve the quality of the study. In the following document we have addressed all the comments of both reviewers (replies in blue) and have made the accompanying changes in the manuscript.

Reviewer 1

Major Comments:

Reviewer Comment: 1. Why did the analyses of mediolateral hip and ankle torques focus on their values at the time of minimum MoS? It would seem that these torques could be just as important for braking/accelerating the CoM in the mediolateral direction at all other time points in the gait cycle. I think that it is particularly important to justify this decision, as it appears to have a major impact on the results. Based on Figure 4, it looks as though choosing to quantify the peak torques rather than the torques at minimum MoS would produce exactly the opposite results. This makes it hard for me to think that the final sentence in the first Discussion paragraph is fully justified (which seems to argue for the preferential importance of the ankle and hip strategies at slower speeds).

Author Response: The intent of investigating the minimum MoS events specifically was to focus on times where additional stability support might be required. As a result, the minimum MoS does not necessarily always occur at the same time in the gait cycle which avoids the results of the analysis being a result of a normal gait artefact rather than a reaction to provide stability. We do concede in the limitations that this is not a perfect method of looking at gait stability compensations, and the application of a perturbation might allow for better insights. However, if the analysis was restricted to just the max and min events, the results observed may be more related to energetics than reactions to a reduction in stability. We have amended the methods section to explain the reason for focusing on the minimum MoS event.

"The analysis at the minimum MoS event was to investigate the reaction at the point where additional balance support was most likely to be required. If the analysis strictly looked at the overall behavior or the maximum and minimum torques, the results may not have necessarily been related to stability as other considerations may have influenced the behavior, for example speed-related torque scaling or energetic efficiency."

Reviewer Comment: 2. To help readers, I think the organization of the Results could be improved, as they seem to jump around a bit. It took me a few times reading through this section before I was confident I was understanding the results correctly. Specifically, presenting the results in a consistent order would be helpful. Currently, the first paragraph of the Results refers to changes in MoS, then XCoM, then trunk CoM excursion, and so on. But the rest of the Results starts with trunk CoM excursion, before later jumping back to XCoM and then MoS results.

Author Response: The first paragraph was organized in order of the most important main result following all the supporting results. We do recognize that this could be confusing for the reader, so we have elected to change the first paragraph to reflect the order in which the results are presented.

"As gait speed slowed, the lateral excursion of the trunk CoM and body CoM increased and the BoS remain relatively constant. This resulted in a lower MoS at slower speeds as the rate at which the lateral position of the XCoM increased was faster than that of the lateral position of the CoP. At the minimum MoS event, the ankle eversion torque and hip abduction torque also grew in magnitude as the gait speed slowed."

Reviewer Comment: 3. Also, presenting the results with a consistent structure would be helpful. In some cases, the results are presented as dimensionless variables, while in other cases they are not. For example, the first full paragraph on page 5 states that average minimum MoS decreased linearly at 0.02 m/ms-1. But the corresponding table appears to state that this metric changed with a slope of 0.07 (dimensionless). Also in some cases, the rate of change of various metrics with altered walking speed are presented in numerical values (as above), while in other cases they are presented as a proportion of the rate of change of other metrics (e.g. "1.4 times greater than the rate at which the CoP moved laterally"). It would be simpler for readers if the structure of the presented results was consistent.

Author Response: The goal of presenting the results with and without units was to provide a physical representation for the results to allow the reader to understand the magnitude of the gait changes as speed varied. The data was converted to its dimensionless form to allow for analysis across the subject group. However, we do understand your concern that this may be a confusing way to present the results. In order to help the reader understand that we are presenting the result in two different forms (dimensional and dimensionless), we have added additional axis with SI units to the figures. In order to be more consistent, we have added the dimensional slopes for all values presented in the text. We elected to keep the proportionalities as well to demonstrate how values have changed relative to one another when appropriate.

Reviewer Comment: 4. I am having a hard time making sense of the combined results presented in Figures 2 and 3. I would expect that the minimum margin of stability (presented in Figure 2) would be equal to the difference between the CoP position and XCoM position at the time of the minimum margin of stability (both presented in Figure 3). But this doesn't appear to be the case. The difference between these values in Figure 3 appears to be approximately constant across gait speeds – around ~0.03. But in Figure 2, the MoS varies widely – from below 0.01 to over 0.03. Am I misinterpreting these figures?

Author Response: The values in Figure 3 have been centred and the rectified to account for treadmill drift as well as the left and right averaging. We have added an explanation to the methods section regarding how the centring was conducted. This causes the values presented to appear slightly different. However, calculating the margin of stability using the centred data will achieve the same result presented in Figure 2. Additionally, the larger slope of the trunk line makes it appear as if the lines for the XCoM and CoP are parallel. However, this is not true as seen in Table 1. The slope of the XCoM is steeper than that of the CoP, causing the MoS to change as a function of speed.

"Each stride was centered such that the body CoM position began at the origin of the lab reference frame to avoid potential effects from subjects drifting on the treadmill during the trials. This behavior

was averaged between the left and right minimum MoS events, and the distances were expressed as the absolute value from the origin of the lab reference frame."

Minor Comments:

Reviewer Comment: 1. In the second full paragraph on page 3, I suggest more explicitly stating whether the referenced "decrease in stability" and "increase in stability" accompany an increase or decreased walking speed.

Author Response: We agree that this change makes that paragraph clearer and have altered it as shown.

"Using Lyapunov exponents to evaluate stability between 0.62 m/s and 1.72m/s, Bruijn et al. [10] found that the long-term local divergence exponent suggested a decrease in stability as walking speed decreased. However, their overall results were inconclusive as they also found that the short-term exponent, which is perhaps more closely related to stability [21], suggested an increase in stability as walking speed decreased."

Reviewer Comment: 2. In the Introduction (4th full paragraph on page 3), the limitation of previous work not including electromyographic activity of upper body muscles is mentioned. As far as I can tell, the present study also did not include electromyographic measurements. I suggest including this in the limitations of the Discussion, and ensuring that the manuscript does not unintentionally imply that such measurements were made (as with the references to peroneus longus activity on page 8).

Author Response: We had added a statement to the limitations paragraph to ensure that it is clear that we did not include electromyographic measurements in this study.

"The current study also did not include electromyographic measurements which limited the ability to determine if the observed results were from passive mechanics or active control."

Reviewer Comment: 3. What were the instructions to participants (if any were provided)? I would imagine that walking on a treadmill at 0.1 m/s would not have been a natural task for these participants. At this speed, did "walking" appear to be a continuous motion for all participants? Or was it more of a sequence of discrete steps, with pauses in between?

Author Response: The data used in this study was obtained from an open dataset where the data was collected by researchers outside of the authors of the current study. To the best of our knowledge the subjects were given no specific instruction on how to walk. In the previous study (see reference 24 figure 1 and 2) it appears that the step timing behavior of the subjects was much more variable which may be due to the unfamiliarity of slow walking or is possibly a direct effect of slow walking.

Reviewer Comment: 4. The results reference changes in mediolateral CoM velocity and mediolateral CoM acceleration values. Are these peak absolute values of these metrics?

Author Response: The mentioned changes in the mediolateral velocity and acceleration reference the range of the velocity and acceleration (fits shown in Table 1). We have modified the sentence for clarification.

"Despite changes in gait speed, the mediolateral CoM velocity range remained similar across speed conditions (Figure 1B and Table 1). As the amplitude of the CoM motion increased and the velocity remained constant, the range of the mediolateral acceleration of the CoM decreased as speed slowed (Figure 1B and Table 1)."

Reviewer Comment: 5. While acknowledged in the Discussion, I think it would be beneficial to explicitly state in the Methods that metric values for the two legs were averaged together, and to justify this decision.

Author Response: In the methods we have added that all the metrics reported are the average of the right and the left leg and provided the rationale for conducting the analysis this way. Additionally, we have added supplementary material to demonstrate both the asymmetry and the variability in the torques specifically.

"All the analysis was averaged between the right and left leg as the intention of the current study was to evaluate overall stability during gait rather than asymmetrical gait behavior. Since the analysis was for healthy subjects, it was assumed that gait would be relatively symmetric."

Reviewer Comment: 6. In Figure 2, what are the shaded colored areas around each line?

Author Response: The shaded region around each line represents 1 standard deviation of the trajectory. We have modified the caption to communicate this.

"(A) Average trajectories of the total CoP, body CoM and XCoM (solid trajectories) with one s.d. indicated (shaded trajectories)."

Reviewer Comment: 7. In the first paragraph of the Discussion, I think this should be "amplitude of the trunk CoM displacement…".

Author Response: We agree with this change and have fixed it in the manuscript.

Reviewer Comment: 8. The first paragraph of the Discussion states that step width remains unchanged, but I don't think this result was actually presented here.

Author Response: We did not recalculate the step width in the current study as this result was presented in the previous study using this data. We did state in the final paragraph of the introduction that the previous study had already established this and to ensure that there is no confusion in the discussion, we have reworded the sentence to re-iterate that the results for step width were found previously.

"Based on the increased stance time and unchanged step-width at slower speeds reported in the previous study [24] using this data set, we expected that the ankle strategy would be more dominant as gait speed slowed."

Reviewer Comment: 9. Figure 3 refers to the "average lateral position" of several metrics. This is the average position relative to what? I would imagine that some sort of correction would at least need to be made to account for combining the left and right legs.

Author Response: The average lateral position was relative to the lab reference frame which was located at the center of the treadmill. Each stride was centered to start at the origin of the reference frame to avoid issues with subjects drifting on the treadmill. To combine the left and right legs the absolute values of each were averaged as the coordinate system was located at the center of the body. We have updated the methods to explain this process (same updated text as for Reviewer 1 Major Comment 4).

"Each stride was centered such that the body CoM position began at the origin of the lab reference frame to avoid potential effects from subjects drifting on the treadmill during the trials. This behavior was averaged between the left and right minimum MoS events, and the distances were expressed as the absolute value from the origin of the lab reference frame."

Reviewer 2

Major Comments:

Reviewer Comment: Page 4: "Specifically, the trunk and CoP positions were used to evaluate the contribution of the upper and lower body to the change in the MoS."; With respect to what were these positions calculated? Was this simply with respect to the lab reference frame, or with respect to the stance leg (CoP?)?. This also holds for figure 1b and 3. If these positions are in lab coordinates, how did the authors cope with potential drift on the treadmill which could affect outcomes then?

Author Response: To account for the potential drift of the subjects on the treadmill, each stride was centred such that the body CoM started each stride at the origin of the lab coordinate system. The absolute value of the left and right behavior was averaged to correct for the coordinate system being at the center of the body. We have updated the methods to explain this process.

"Each stride was centered such that the body CoM position began at the origin of the lab reference frame to avoid potential effects from subjects drifting on the treadmill during the trials. This behavior was averaged between the left and right minimum MoS events, and the distances were expressed as the absolute value from the origin of the lab reference frame."

Reviewer Comment: Page 4:" the ankle eversion torque and hip abduction torque also grew in magnitude as gait speed slowed." While this is true for the ankle eversion torque, at minimum MOS it doesn't seem to be true for the hip abduction torque, at any point, or peak ankle eversion torque (cf figure 4, lower panels?)
Also, later, the authors seem to realise this, page 5: "Similarly, the hip torques were similar among the different gait speed conditions but with reduced peak magnitudes as well (Figure 4A bottom)". All in all, it seems that the description of the data is not in line with the data presented. Even within figure 4 (lower panels), we seem to see a decrease in hip abduction moment magnitude at minimum MoS with decreasing speed, yet lower panel b indicates an opposite relationship. How is this possible? Needless to say, this has influences for the discussion as well.

Author Response: The graphs displayed in the left side of Figure 4 is the average waveform of the torques on the right side. However, the data used to create regressions shown in Figure 4B are from both the left and right side, which were slightly different from each other. To provide the information required to see this, we have added the waveforms of the left side to the figure as well. Additionally, the

torques from both legs display some amount of variability, making it difficult to directly translate the observations in Figure 4A to Figure 4B. To demonstrate the variability, we have included a supplemental figure showing the waveforms for the left and right side along with the one standard deviation of the waveform.

"Additionally, we reported the average behavior between the left and right legs but found some asymmetric behavior between the two legs as well as some variability (Figure S1) that was not further analyzed."

Reviewer Comment: Page 8: "These inconsistent findings … redirect the ground reaction force": but wouldn't increased eversion redirect the CoP in medial instead of lateral direction, and thus be undesired?

Author Response: We agree with you that the increased ankle eversion would redirect the CoP medially which would be undesired. What we meant by redirecting the ground reaction force is that the increased ankle eversion could possibly increase the medial component of the ground reaction course, accelerating the CoM medially which would be beneficial to gait stability. We have reworded this in the manuscript to make it clearer.

"These inconsistent findings suggest that the increased ankle eversion torque does not necessarily serve to counter an increased ground reaction force but instead could possibly control the location of the CoP within the BoS or redirect the ground reaction force by controlling its medial component."

Minor Comments:

Reviewer Comment: Introduction page 3: "the percentage of gait spent in stance increased."; as walking gait doesn't have a flight phase, the % of stance is always 100%. More precise and correct would be "the % of [single or double] stance". Or "the % of stance time of a leg"

Author Response: We agree with this change and have modified it in the manuscript.

"Wu et al. [24] investigated speeds as low as 0.1 m/s and found that as gait speed slowed, the percentage of gait spent in stance of each leg increased."

Reviewer Comment: figure 2a is not clear, as not all lines can be seen. Also, it appears that the XCoM is outside of the COP for quite some time. Does this have to do with using a combined COP from two forceplates? What if single forceplate COP would be used? Either way, it would be good to have the figures somewhat larger so that they can be read.

Author Response: We have increased the opacity of the shading around the trajectories to attempt to help the legibility of the figure. The XCoM does appear to be outside the CoP during double support (shaded regions), which is due to the total CoP transitioning from one foot to the other. During this period, the XCoM would be between the separate CoP of both feet so stability is still achieved. If the data was collected using a single force plate, the results should be the same when looking at the single support region (as we did) as only one foot is in contact in the ground. We also increased the opacity of the shaded double support regions to better highlight the single support region.

BioRxiv Comments

In addition to the comments and feedback from the reviewers, we also received comments from other researchers that viewed the article through bioRxiv. The comment that was brought to our attention was that Hof's original definition of the MoS defined MoS as the distance from the XCoM to the lateral edge of the BoS. In this paper, however, we calculated the MoS as the distance from the XCoM to the CoP. We found that the concern of the differing definitions was valid and required some reasoning in the manuscript. We have amended the manuscript as follows to address this concern.

Author Response: In Hof's original study, the MoS was defined as the distance from the lateral edge of the BoS. However, the CoP has been used to estimate the BoS as it the CoP cannot exceed the upper limit of the BoS and the CoM acceleration is proportional to the distance between the CoP and CoM [12,14,27]. We agree that it is important to recognize that we have choose to define the MoS in this manner and provide support for this, so we have elected to update the manuscript.

"The MoS was originally defined as the distance from the XCoM to the lateral edge of the BoS [12]. Using the CoP instead provides a conservative approximation as the CoP cannot exceed the borders of the BoS. This approximation was used for walking in the original MoS study by Hof et al. [12] and in his subsequent studies as well [14,27]."