Dear recommender,
Dear reviewers,

We would like to thank you again for your time and expertise. This work has further improved the manuscript.
Below, please find *the reviewers' comments* in *black and italic* and our answers in blue. In the manuscript, we highlighted the modifications using red fonts.

Dear authors,
The reviewers are satisfied with your answers, but still suggest some minor changes. Once you have taken these into account and the preprint has been updated on BioRxiv, I will write my recommendation.
Best regards,
Matthieu Boisgontier

Review by Pierre Morel, 21 Aug 2024 07:56
I commend the authors for addressing the major concerns of reviewers, thoroughly answering the questions that were raised, and doing substantial changes to the paper. Notably, the authors included interesting new analyses on the correlation between balance control and movement efficiency changes that strengthen the message of the paper. However, with these important modifications, I still feel that some additional edits in the manuscripts are needed for readability. I will present these below:

We thank the reviewer for pointing out these additional details.

Despite its thorough modifications, I find that the abstract could still be better structured. The early framing of deterioration VS compensation is still not easy to understand in this short form, as does the double negation "decreased [...] efficiency [...] negatively correlated with". An abstract focused on movement efficiency and with less storytelling would be easier to parse, while compensation could be mentioned only with regards to the balance results.
We thank the reviewer for his suggestion. After careful consideration, we feel that removing the concept of compensation from the first part of the abstract would be detrimental to the message we want to convey with this work. We strongly believe that age-related compensation is a core concept that needs to be better understood in the sensorimotor field. For this reason, we would prefer to keep it throughout the introduction. As requested by the reviewer, we largely rewrote the abstract in the previous review round. We believe this has greatly improved its structure and thank the reviewer again for pointing this out. Here, to try and improve readability even more, we performed additional modifications (please **see lines 18-21**). In particular, we have removed the unnecessary negative form in the sentence mentioned by the reviewer (please **see line 31**).

The more focused and streamlined introduction is appreciated. Since the authors mention that they use "effort" and "efficiency" somewhat interchangably (more on that in a comment below), I find the sentence L93-95 difficult to parse. More importantly, the end of the

introduction should be amended to prepare the reader for the new analysis/results: balance is not mentioned in the introduction.
We thank the reviewer for his comment. The sentence **lines 93-95** was indeed poorly written. We split it in two to ease readability (please **see lines 91-94**). More, we added a sentence at the end of the introduction to account for the new analysis on balance control (please **see lines 106-107**).

Line 125 typo: whole [B]ody
We have taken this comment into account (**See line 124**).

Lines 122-123 and legend of figure 1: WBR tasks still mention "a" target instead of two
We have taken this comment into account (**See lines 121-122**).

Line 207: The use of the right shoulder marker for the detection of movement onset makes sense only for the whole body task, precise which marker was used for arm movements.
Indeed, we thank the reviewer for bringing this to our attention. We have taken this comment into account. See "*using the marker of the right shoulder (for whole-body movements, see Figure 2), or the right finger (for arm movements).*" (**See line 207**).

Lines 230 to 243: This additional paragraph about effort seems misplaced in the methods. Core concepts should be presented in the introduction (some already are), and/or recalled in the results for understandability. I'm puzzled by the sentence "we interchangably use "energetic efficiency" and "effort minimization" in the present work". If that is the case, I would strongly suggest that the authors consistently use one term only throughout the paper for clarity. Since "effort" can have a subjective connotation, "efficiency" would seem to be the most appropriate term given the framing of the paper.
We thank the reviewer for this suggestion. We moved this paragraph to the beginning of the results section and, throughout the paper, adopted the systematic wording "energetic efficiency" instead of "effort-minimization". We kept the wording muscle-effort (which is not ambiguous as "muscle" is specified) twice in the paper, where we quote studies that used this wording.

Line 247: reference [Mat, 2021] seems wrongly formatted
We have taken this comment into account. See "window using trapezoidal numerical integration from Matlab (Mathworks, Natick, MA)" (**See line 235**).

Figure 3: indicate again what is TA, T and NA in the legend.
We have taken this comment into account (**See legend of the Figure 3**).

Line 276: The nomenclature "Erector Spinae D7 (ESD7)" was not correctly updated here to EST7 and elsewhere, notably in figures.
Thank you for highlighting this point. We have taken this comment into account (**See Figure 8 and lines 265-266**).

The dismissal of SOL and EST7 as postural rather than focal would deserve more explanation / justification.

We thank the reviewer for pointing this out. We have taken this comment into account. By definition, a postural muscle does not change much in length during a given task. Because here we test whether the motor system takes advantage of gravity effects to move our body-limbs, studying muscle that act at joints that barely move is not appropriate. As can be observed from Figure 1, the ankle and upper-rachis joints are barely mobilized compared to other joints such as the hips and knees. Including these muscles in our analyses would thus add noise to our dependent variables and likely impede our ability to test our hypothesis. We made this more explicit **lines 268-272**.

Lines 300-308: Given the major concerns in the first round of review I understand the justification here, but it would now read too "defensive" for a first time reader. I feel that the main rationale should better be presented elsewhere than in the methods. Moreover, now that the authors confirmed that the machine learning was not used to select muscles of interest, I question its presentation before the main results. Could this analysis be better framed as a confirmation of the main results: antigravity muscles in whole body tasks are indeed the ones that separate subjects by age?
Thank you for bringing this to our attention. We moved this paragraph into the results section. As suggested, the Machine Learning results were moved towards the end of the results section (**See line 430-440**).

Figure 6: Typo "height" instead of "eighth". On panel B I would suggest adding a line representing chance level as well as ordering the muscles by accuracy to show that antigravity muscles have the highest. The relatively high score of some non antigravity muscles (like DP) could be discussed.
We thank the reviewer for his thoughtful suggestion. We have modified and improved the figure accordingly (please **see Figure 8**). We have also added a few lines to acknowledge that other muscles also present a good classification accuracy (although not as good as the main muscles in our study, please **see lines 436-440**). The most basic point to discuss here is that humans and animals are known to control their varied muscles in a synergistic manner (Berret et al., 2009; d'Avella et al., 2006; Tresch et al., 1999). Thus, that other muscles also show age-related modifications is expected. A deeper discussion of the machine learning results, such as why the DP also shows above-chance classification accuracies, would require a lot of speculation. It could be because DP plays a postural role during whole-body tasks and posture is controlled differently in older and younger adults. It could also be because arm movement control is more efficient in older than younger adults (Healy et al. 2023; Poirier et al. 2020). Because this result only represents a minor point in the present manuscript, and the manuscript is already quite long, we would rather not expand and speculate too much on this aspect.

Review by Florian Monjo, 18 Aug 2024 07:48
I appreciate the authors' significant efforts in revising the manuscript.
Overall, they have satisfactorily addressed my comments.
Thank you for pointing out the additional details below.

However, a few minor issues remain, particularly some errors in the text.
Line 216: Please replace “analyse” with “analysis.”
We have taken this comment into account (**See line 216**).

Line 219: Remove the parenthesis before "Winter" and place it before the year.
We have taken this comment into account (**See line 219**).

Line 222: Replace “ofsset” with “offset.”
We have taken this comment into account (**See line 222**).

Line 230: Replace “rational” with “rationale.”
We actually removed this word to answer another comment.

Line 234: Enclose the year in parentheses.
We have taken this comment into account (**See line 332**).

Line 301: Consider revising the sentence to: "Scientific literature has reported that the control of whole-body movements changes with age, while the control of arm movements does not."
Line 483: Remove the "s" from "harvests."
Indeed, it makes it clearer. We have taken this comment into account (**See line 414**).

Regarding your response to the comment on oral consent ("The French National Ethics Committee (2019-A01558-49) approved the experiment to be conducted with oral informed consent only. Nonetheless, each participant was included in the study by a medical doctor."), it might be worth incorporating this information into the text.
We have taken this comment into account (**See line 117**).

Review by Zack van Allen, 24 Jul 2024 15:05
The authors have addressed all my comments adequately and I have no further comments to add.