PeerJ Review:

Changes in muscle activity during the flexion and extension phases of arm cycling as an effect of power output are muscle-specific (#48201)

Overview:

This interesting investigation considers the electrical activity of targeted muscles during arm crank ergometry. The manuscript is structured appropriately and a good writing style is employed.

Workers have considered how electrical activity varies according to a wide range of external power outputs, as well as two distinct (push-pull) phases of the crank cycle. Data is original and adds to existing knowledge, but I have identified a few methodological issues that require some consideration and acknowledgement within the manuscript. Authors identified that this exercise mode is relevant in the context of (clinical) rehabilitation; can authors, therefore, please consider/ identify how their findings may lead to practical applications.

Abstract and Introduction:

In Lines 25-26 you state: "***Arm cycling is commonly used in rehabilitation settings for individuals with motor impairments…***", however, is there much evidence to suggest sprint-based activity often forms a part of a training regime, or is used to prescribe relative training intensities within a rehabilitation setting? There may well be, but if not, what was your rationale for using a participant's performance during an all-out a sprint test as the basis to prescribe exercise intensities. You described a power output value of 25 W as "…***a low cycling workload***…" (Line 96), but, conversely, is it possible that the values of power you employed are too high? I highly recommend that you report values of power output (mean (±SD) W) associated with your sprint PPO and 5 to 50% PPO (submaximal?) range.

Line 44: It is conventional for "key words" to be different to those included within the title of the manuscript – please review.

Line 48: "***Arm cycling, also referred to as arm pedalling…***" – within the literature, the correct term for this mode of exercise is "arm crank ergometry" – you have used a seated and unrestrained version.

In Lines 82-85: You have stated "***These EMG relationships are further complicated between cycling phases. During arm cycling, data is frequently discussed in terms of the two main propulsion phases; the flexion phase, which pulls the handle towards the individual (driven by the elbow flexors), and the extension phase, which pushes the handle away (driven by the elbow extensors).***"

The paper by Smith *et al*. (2008; Journal of Electromyography and Kinesiology. **18**: 598–605) is relevant, here. These authors provided detailed information relating to phase-dependency of surface EMG activity, during both synchronous and asynchronous seated arm crank ergometry.

Indeed, the publication by Smith *et al*. (2008) is also relevant in the context of your statements provided in Lines 99-100 and Lines 326-327: "***There are only three studies that have shown the influence of workload on EMG of the arm 100 musculature during cycling (Bernasconi et al. 2006; Hundza et al. 2012; Spence et al. 2016).***"

Methods:

Lines 133-140: You employed two different pieces of equipment during exercise testing; a Monark (Ergomedic 894 E) ergometer for the 25 W and 5-50% PPO exercise bouts and a SCIFIT cycle ergometer (model PRO2 Total Body) to establish PPO. In terms of precision, how confident are you that the measurement of power was consistent between these very different pieces of equipment? Is this another "*Methodological Consideration*?"

Lines 136-137: "…***participants performed a 10 second maximal arm ergometry sprint using 5% of their body weight as the resistance to determine PPO.***"

As requested above, what was the mean (±SD) values of (mean) sprint power? In my experience, using arm crank ergometry, participants are often able to produce 3 to 4-fold the amount of anaerobic power, compared to power achieved during an aerobic (VO_2peak) test to exhaustion, which is an exercise testing procedure more often used as the basis for subsequent prescription of relative exercise intensities.

Lines 140-143: "…***to perform arm cycling at 11 different intensities, 10 of which were made relative to the PPO and one which was done at 25W. The 25W condition was constant for all participants, given that 25W is a common workload used during arm cycling studies (Bressel et al. 2001; Forman et al. 2014)***."

It strikes me as being a little incongruent that you selected a 20 s trial to be conducted using 25 W, while all others were based upon a proportion of each participants' 10-s sprint PO. From Figs 2A-F, I think I am right in my interpretation that the average EMG signal associated with the 25 W trial was the lowest for all targeted muscles. This further brings into question the rationale and justification for using a sprint test as the basis of subsequent exercise prescription and the relevance of your 5-50% 10-s sprint PO trials in the context of (clinical) rehabilitation.

Also, in the context of prescribing relative exercise intensities, is the method you have used consistent with that employed by others, irrespective of exercise mode employed (*i.e.*, either during leg or arm crank ergometry research)?

Perhaps I am being pedantic (apologies), but during standard exercise testing (*e.g.*, during a 30-s, all-out Wingate anaerobic test) PPO is typically measured over a duration that is much shorter than 10 s. During the 1970s, PPO was typically measured over a 5 s interval, but more recent studies have reported PPO at either a 1 s interval, or for a single crank cycle, or even the drive phase of a single crank cycle. Therefore, to avoid confusion with established terminology, I suggest that you refer to your reference sprint data as "mean anaerobic power output" ($MPO_{an\text{-}10}$) or something similar.

As mentioned above, I would suggest that researchers more often base their prescription of submaximal, relative exercise intensities upon a measure of peak aerobic power output (Wpeak), or set exercise intensities relative to a submaximal metabolic threshold. Therefore, based upon your mentioning of (clinical) rehabilitation applications, you should identify variations that are likely to stem from different approaches within the "*Methodological Considerations*" section.

Linked to this point, in the context of worthwhile practical applications, how will your methodological approach and data (knowledge) facilitate how a (clinical) rehabilitation specialist / recreational therapist approaches the issue of exercise intensity prescription for training purposes? Offer recommendations for practical applications, if possible.

In Lines 73-74, you refer to cycling exercise and identify the fact that: "***The activation of various muscles during leg cycling has been studied in detail, with the influence of factors such as pedalling rate and workload having been examined***…"

Therefore, a further point to consider, in the context of the meaningfulness and practical applications of your work, is this. Often, as exercise scientists, we consider exercise scenarios acutely; for example, you have employed very brief, 20 s exercise bouts, used 10 s worth of data and then drawn firm conclusions from this. However, Takaishi et al. (1996; Medicine and Science in Sports and Exercise. **28**: 1492-7) established that the extent of surface EMG, measured across a range of exercise intensities with varying cadences, changed considerably with exercise time. Therefore, you should identify this as a clear limitation of your methods and perhaps offer a suggestion for future research.

Lines 158-160: You state: "**Cycle crank positions were made relative to a clock face (12, 3, 6, and 9 o'clock, as viewed from the right crank arm) with the "top dead centre" position of the crank arm defined as 12 o'clock and "bottom dead centre" as 6 o'clock**."

This is a simple and convenient view of the pattern of propulsion, but the work and findings of Smith *et al*. (2008) should assist you in justifying this decision.

Lines 186-187: Due to the considerable variation in crank speed during the 10-s sprint and all sub-maximal workloads (60 rev·min^{-1}), an alternative approach would have been to consider the relative gain in EMG activity in relation to the standard workload of 25 W. This approach would remove the potentially confounding variable of "crank speed variation", altogether.

Results:

Due to the nature of this work, the Results section is quite long, but the section is adequately structured and workers have presented their findings clearly; a good variety of narrative descriptions and associated Figures and Tables are evident.

Discussion:

Lines 320-321: It is interesting that the pattern of EMG activity of the *m. triceps brachii* (TB; lateral head) and *m. extensor carpi radialis* (ECR) was different to that of other targeted muscles. With respect to the ECR and FCR, a participant's wrist becomes relatively fixed during arm crank ergometry, especially at higher power outputs. This is likely the result of an active grip, which is required to engage and transmit effective, propulsive forces to the crank arms; this is unlike leg cycling, where the foot sits on the pedal and is usually attached either using toe clips or cleats.

Discussion subsection starting on Line 324: The work published by Smith *et al*. (2008) is relevant here.

Line 347: Minor, but please change "…~~lab's~~…" to "…laboratory's…"

Lines 403-406: The plateau in EMG activity may be due, in part, to the contribution of other components within a complex kinetic chain, something referred to by Smith *et al*. (2008). From our considerable experience, where a closed-chain set-up is employed (with a participant's feet in contact with the ground), it is clear that there is a disproportionate increase in torso and lower extremity activity with increments in power output.

Lines 435-436: As mentioned above, the confounding issue of variations in crank rate and EMG activity could have been avoided altogether if data had been normalised and presented as a proportional gain above the nominal power output of 25 W. I am not suggesting colleagues rework their data, however, they may wish to consider using this alternative approach during future investigations.

The previous point links to your comment in Lines 443-445: "***It is also important to recognize that arm cycling is a complex motor output that involves the activation of many muscles working at several joints, bilaterally***." This is true, but you should not discount the involvement of the back, abdominal region and lower extremities – especially in light of the range of power outputs used.

END