Biomechanics
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Lecture - 74
Wrist Posture and Finger Interdependence - 3

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(FL) Welcome to this video on biomechanics. We have been looking at finger enslavement. How finger enslavement may or may not change as a function of wrist posture. In the previous videos, we were looking at the background for this study on wrist posture and finger interaction or finger interdependence. Then we also looked at the experimental approach and the data analysis approach and the statistical methods that we used for performing this study.

In this video we will be discussing the results and perhaps the discussions or the interpretation or inference and the implications of this study for human hand biomechanics and motor control.

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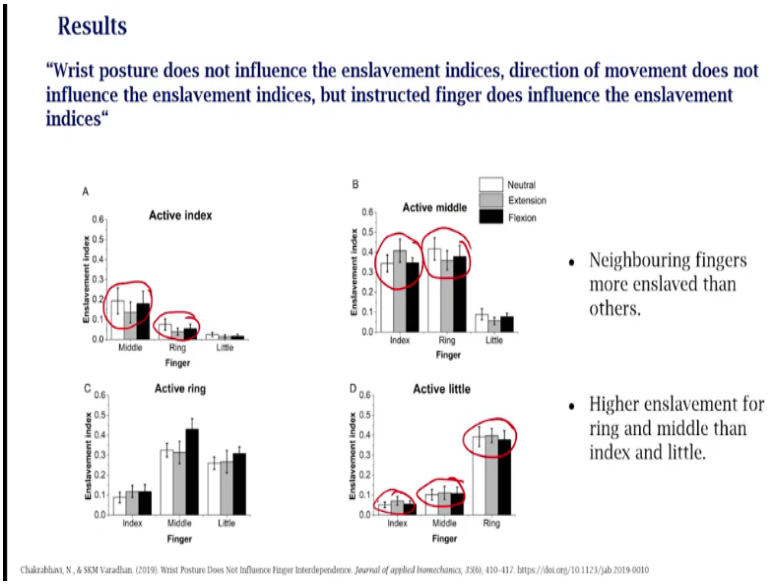

What we found was that wrist posture did not affect the enslavement index and direction of movement also does not appear to influence the enslavement index, but which finger is instructed finger dies affect the enslavement index. Well that means depending on whether you are the index finger, middle finger, ring finger or little finger enslavement index changes but the direction of movement of the finger does not affect the enslavement.

The posture of the wrist as a neutral or flexion or extension does not affect the enslavement that is what we find. So what is shown in all these white bars represent neutral, all these gray bars represent extension and all the black bars represent flexion. We are interested in establishing primarily a difference between the white bars, gray bars and black bars. Are the heights of these bars different in a given condition and in a given situation that is the question that we are asking.

Of course, these heights are lower than these heights, actually these are two different fingers. Let us take the ring finger, these heights are different from these heights. Here the enslavement index of the ring finger when the middle finger is active is about 0.4, when the index finger is active it is about 0. 05. Well that makes sense right because as per the Zatsiorsky and the previous studies the distance of a given non-instructed finger from the instructed finger matters.

Because of this reason it is likely because the ring finger is far away from the index finger, but it is the neighbour of the middle finger, you could expect to see a higher enslavement when the middle finger is the active finger when compared with the index finger is active finger. So,

these finger level differences are somewhat clearly obvious and are also explainable. It is possible to explain this, but the question is not that.

The most important question is not that, the most important question is in a given active finger is a given non-instructed finger showing a difference in the enslavement index for the three coloured bars are the white bars, gray bars and the black bars different, within this are they different, within this are they different, within this are they different, within this are they different, within this are they different?

I am only interested in comparing the heights of these three coloured bars; white bar, gray bar and black bar within a condition and within an instructed finger that is my interest and it appears throughout, everywhere it appears like the white bar in a given active condition and in a given this are not very different. By the way these error bars are standard errors of means, we had 8 participants participated in the study. So, these are standard errors of mean.

Of course, we observed the neighbouring fingers are more enslaved than the distant fingers and we observed that the enslavement is higher for the middle finger and the ring finger when compared with the other fingers, index and little fingers. These are all not new, these are all already known, but what we showed here is that there is statistical non-difference between these three postures; neutral posture, flexion posture and extension postures that is what we showed.

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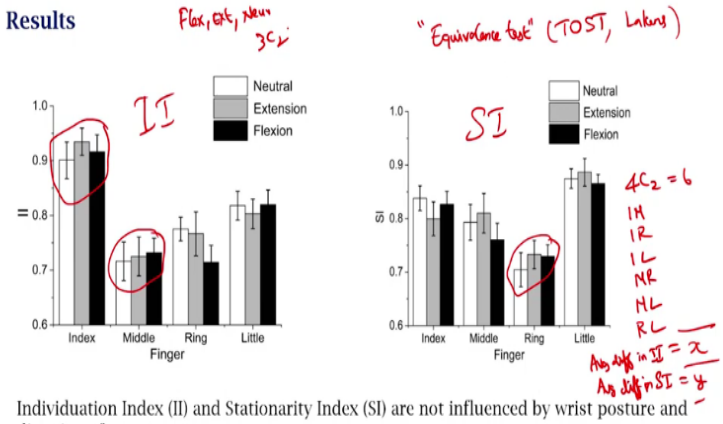

Individuation Index (II) and Stationarity Index (SI) are not influenced by wrist posture and direction of movement

Average differences between wrist postures were much smaller than the average differences observed between the fingers.

Chakrabhavi, N., & SKM Varadhan. (2019). Wrist Posture Does Not Influence Finger Interdependence. *Journal of applied biomechanics*, 35(6), 410–417. https://doi.org/10.1123/jab.2019-0010

So we also performed this analysis on the individuation index and the stationarity index. This is the individuation index data and this is the stationarity index data. Again, our interest is to compare II within a given finger. I take II of the index finger and I compare it across the three postures, I take SI of the ring finger and I compare it across the three postures, this is my interest. And again these are standard errors of mean, the error bars are standard errors of mean.

And I find that these are actually not different from each other that the three bars; the white bar, gray bar and the black bar are the neutral this posture, the flexion this posture and the extension this posture are showing no big difference in either the individuation index or the stationarity index. So the individuation index and the stationarity index were not influenced by wrist posture and direction of movement.

Importantly we found that the average difference in enslavement between the three wrist postures was much smaller than the average difference between the enslavement of fingers. So, this is what we used as the smallest effect size of interest and we performed what is called as the equivalence test or the two one-sided test approach as was proposed and suggested by Daniel Lakens. We performed this test and we used the average difference between fingers.

The enslavement difference between fingers as the smallest effect size of interest, if there is at least that much difference as observed between fingers, between wrist postures, let us say the average difference in enslavement between pairs of fingers what are the various pairs that are possible, 4 choose 2 is it not that is 6. What are the 6 possible combinations? Index middle, index ring, index little, middle ring, middle little, ring little.

And I compared the enslavement between essentially either the individuation index or the stationarity index or perhaps even both between these two fingers index and middle, index and ring, index and little, middle ring, middle little and ring little and I find the average difference between these two fingers because there is finger level difference. Now for the index finger II is 0.9 or close to 0.95 but for the middle finger it is only 0.75.

So, between fingers that is considerable difference. If there is a difference in individuation and stationarity index between such distal regions like the fingertips, if there is such a big difference or if there is some difference it would be reasonable to expect that there is at least

that much difference in the more proximal wrist region as I am making such a big moment excursion of the wrist about 60 degrees from 30 degree flexion to 30 degree extension, about 60 degrees change.

It is reasonable to expect at least that much difference as we observe in the finger pair difference. So that is I expected let us say the average difference in individuation index is some x and the average difference in these two, in these pairs stationarity index is some y, let us say for example. I expect to see a difference of x in the individuation index between the wrist flexion and wrist extension condition and I expect to see at least a difference of y between the wrist flexion and wrist extension condition.

Actually there are three conditions; flexion, extension, neutral, is it not? So there are 3 choose 2 possibilities which is 3 flexion and extension, flexion and neutral, extension and neutral, there are three possibilities. But at least between fraction and extension which are two extremes I would like to see at least a difference of x in individuation index and y in stationarity index and so when we performed this equivalence test we actually did not find that difference.

So, the differences between fingers was much greater when compared with the difference in wrist posture, it seems like wrist posture did not matter at all that is what we found. So we not only showed that the individuation and stationarity indices are nondifferent statistically, we also showed that the individuation indices and stationarity indices between the wrist postures were actually statistically equivalent that in my opinion is perhaps the most crucial unique contribution of our paper.

Such a phenomenal analysis Niranjan continuously built on this statistical analysis because the study was done in 16 and this paper by Daniel Lakens if I remember correctly came out only in 17, we latched on to this analysis very early, as early as 18 or something and then we submitted this and that is why this paper was published only in 19. So there are many little details, historical details that I remember as I am discussing this paper.

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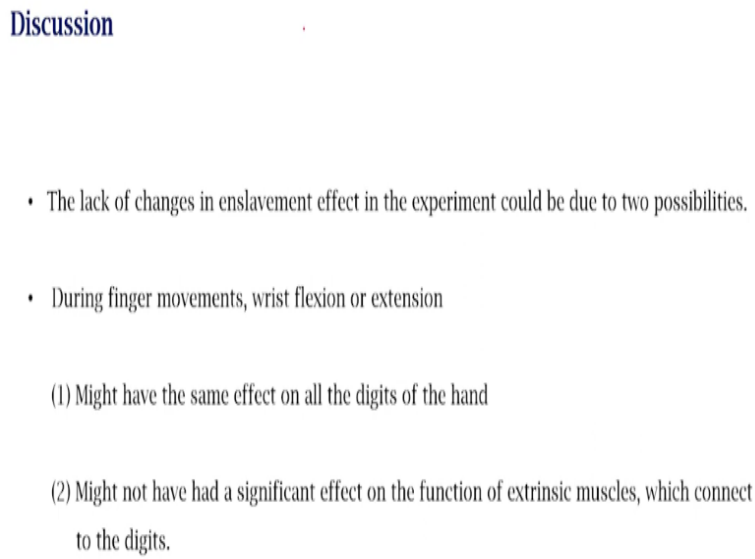

So, what we found was that there was no big change in enslavement index because of the wrist posture, this could be because of two possibilities, maybe because wrist flexion and extension might have had the same effect on all the digits of the hand or it might not have had any big difference, any huge difference on the function of the extrinsic muscle that connects to the digits.

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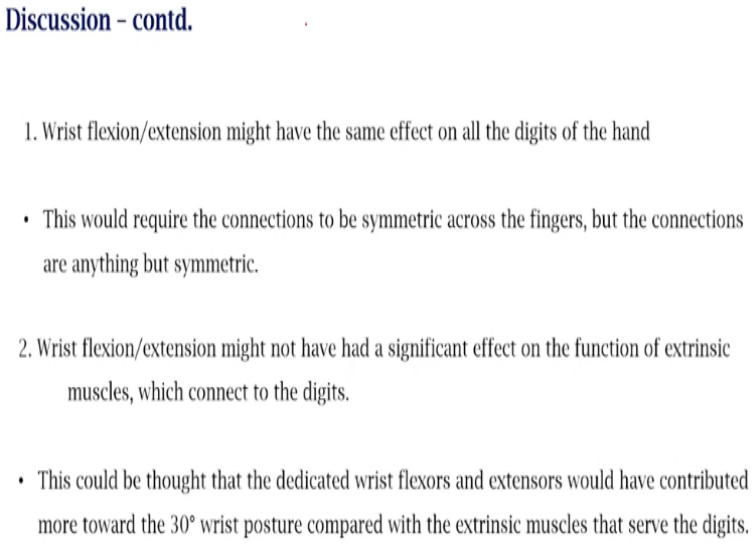

See wrist flexion and extension might if it is that the wrist flexion and extension had the same effect on all the digits that would mean that the connections would be symmetric across fingers, but the connections across fingers are anything but symmetric. Different fingers receive different types of connection, so the connections across fingers are not symmetric anatomically, we know this from our understanding of anatomy.

Wrist flexion or wrist extension or wrist posture might not have had any big difference or any big effect on the function of the extrinsic muscles. This could be because the dedicated flexors and extensors of the wrist would have contributed more towards achieving this wrist posture when compared with the contribution that is made by the extrinsic muscles whose function is to serve the individual digits or the fingers.

So perhaps the muscles that are responsible for finger function did not really participate in wrist flexion and extension, maybe the wrist flexion and extension is more of an independent function that is performed independently by the dedicated flexor and extensor of the wrist when compared with the extrinsic muscles of the fingers. This is the other idea.

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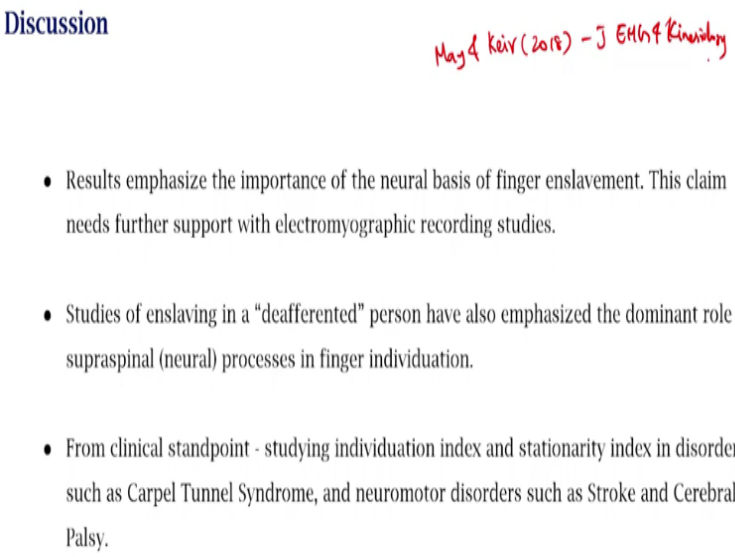

So from all these taken together these results mean that neural factors dominate finger enslavement. Finger enslavement is mostly due to neural factors. Of course, it would be good or cool if we can establish this with the help of electromyography, checking whether a given muscle is active during a particular task or not would really help to further support this idea. There have been some studies that support this idea.

For example, studies of enslaving in a deafferented person have suggested that the supraspinal or the neural effects have a major role in finger individuation. Studying these individuation index and stationarity index in disorders like carpal tunnel syndrome, a neuromotor disorder such as stroke and cerebral palsy could be very useful to understand the nature of these pathologies and how they differentially affect different fingers something that can be considered as future possible extensions of this study.

There was one study by May and Keir I think that was from the group in Canada, this paper was published in 2018 in Journal of Electromyography and Kinesiology in which they compared the effect of force enslavement or the effect of wrist posture on force enslavement and what they found was that some specific fingers they had a higher enslavement dependent on wrist posture. Our results do not agree with these results.

Remember that kinematics and kinetics are essentially two different outputs of the movement control system. It is not like all the results that are found in forces must necessarily corroborate and correlate and completely agree with the results in kinematics. Also, this is just one finger that was behaving differently, not the others. So, there is a little bit of a discussion, debate that continues on this topic.

But our stand and our understanding of this topic is that the wrist posture does not affect finger individuation or finger interdependence at least for the range of wrist postures that we considered in this study. If I change the response to 50 degrees 60 degrees extension and flexion, maybe we will find a different result, but those studies are relatively hard to perform as an experiment, experimentally difficult to perform because participants are not able to complete the task.

This is our observation from our pilots that we performed. So maybe at least for the range of flexion extension angles that we considered which is 30 degree flexion and 30 degree extension that we considered in our study, we found that wrist posture does not affect finger interdependence. There will be a need to perform more studies especially with the help of EMG to either corroborate and find support to this idea or maybe add value by disagreeing with this idea, only future studies can tell us this. So, with this we come to the end of this video.

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Summary…

- Research paper 2*

In this video, we looked at the paper by Niranjan Chakrabhavi and Varadhan SKM published in the Journal of Applied Biomechanics in 2019. Thank you very much for your attention.