Biomechanics
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Lecture - 72
Wrist Posture and Finger Interdependence - 1

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(**FL)** Welcome to this video on biomechanics. In the previous video we looked at finger enslavement in the force domain. We looked at the study by Zatsiorsky, Zong-Ming Li and Mark Latash where we showed that finger enslavement is likely more of a neural phenomenon than a mechanical phenomenon, but it is not a conclusive study, it is pointing in that direction. Following along those lines, in our lab we wanted to continue that line of studies, but here we wanted to study kinematics, not forces but moments.

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So in this video we will be looking at the research paper by Niranjan Chakrabhavi and Varadhan which is myself, so this is work done in our lab, in the neuromechanics lab at IIT, Madras. This work was done in 2015-16 something like that around that time. This paper was published in Journal of Applied Biomechanics in 2019. In this video or in this series of videos, I will first set up the background for performing the study.

Then explain the specific methods, experimental approach that was used to perform the study, then discuss the results and then discuss the inference, interpretation of these results.

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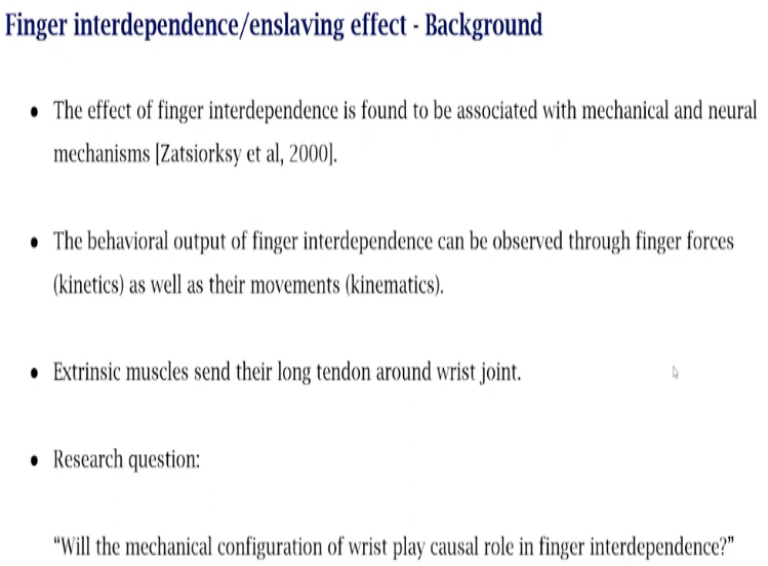

So what is known, well that what is known is that finger enslavement may be due to three factors. We saw that maybe due to mechanical shearing between tendons, there may be sharing between tendons or maybe due to multi-digit motor units, one motor unit that is

muscle fibers from a given motor unit connecting to different fingers, multi-digit motor units or it can be due to the possibility of neural enslavement or the possibility that a given region in the motor cortex is active.

And because in a given region there are neurons that send commands to various fingers, even distant fingers, there may be some form of spillage or some form of command spillage or something similar to co-activation or concomitant activation of neurons in a given area might happen giving rise to the possibility that fingers that are not necessarily neighbours to each other may be activated.

These are the three possibilities that we saw that is simply put that it is possible that enslavement may be due to mechanical causes or maybe due to neural factors neural mechanisms. Of course, the only observable output of the central nervous system are movements and actions, so we can observe it through fingertip forces as was done by Zatsiorsky and his colleagues in 1998 and 2000 and then many other follow-up studies by many other colleagues or we can also study this using finger movements, kinematics.

Remember that the extrinsic muscles whose muscle bellies lie in the forearm send their tendons to the fingers around the wrist joint through the wrist joint and what happens when there is wrap around that happens, these are all those things in a previous video. The question is does the mechanical configuration of the wrist joint cause a change or play a causal role in finger interdependence? This is the question.

Because when the wrist is flexed, the extensor muscle might be stretched, now the tendons of the extensor muscle might be stretched and when the wrist is extended the tendons of the flexors might be stretched. There was one study that showed differential enslavement for specific fingers only in force domain, so we wanted to check. In 2015 when Niranjan came up with this study he was absolutely passionate about this, he wanted to check does wrist posture affect finger movements at all.

We actually thought that in a very big way, we thought when we started out that we were completely biased into thinking that wrist posture of course will affect finger interdependence, why not? Because if I am flexing extensor tendon is pulled or stretched, if I am extending

flexor tendon is pulled or stretched, so obviously this will change the nature of force transmission through the tendon and because of this.

And it is likely that the amount of stretch and how this stretch affects finger movements might be different across fingers. Because of this reason we thought that there will definitely be a difference in finger interdependence based on the wrist posture, this is the hypothesis, this was the working hypothesis.

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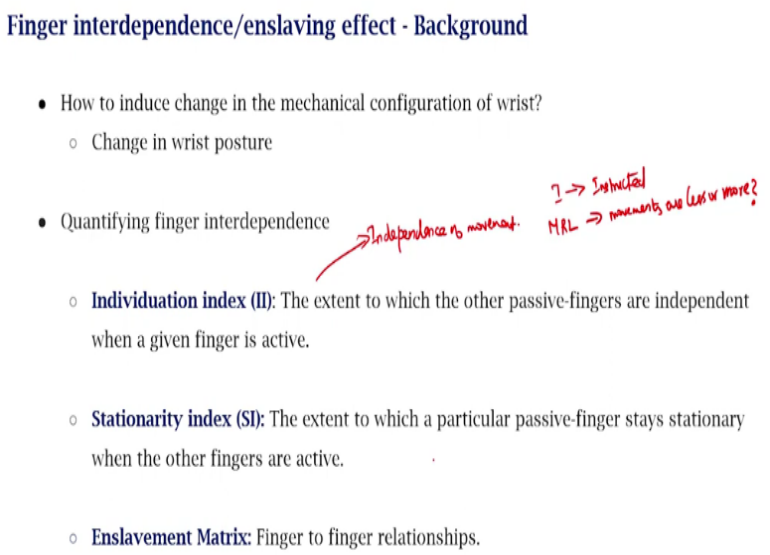

So the question is how to change or how to cause a change in the mechanics of the wrist or essentially how do you stretch the flexors and extensors, simply change the wrist posture and then so I can perform finger movements in this neutral posture for example like this or I can keep the wrist extended like this and then perform that or I can keep it flexed and then perform that.

In some previous studies by the excellent research group of professor Marc Schieber it has been proposed that finger interdependence in the kinematic space can be defined using two indices, one is an individuation index. This is the extent to which other passive fingers are independent when a given finger is active that is I am performing the movement with the index finger, how less the other fingers are moving.

That is how independently a given finger is moving without causing some unnecessary movements in the other non-instructed fingers, this is called as individuation index. How individuated that is independence, individuated means this refers to independence of

movement. Say for example I is the instructed finger, the movements in middle, ring and little; if the movements in middle, ring, little fingers are less that means that the individuation index for the instructor finger is high.

But if the index finger when it moves it also causes some unnecessary or unwanted or undesirable movements in middle, ring and little fingers that means that the movements of the index finger are not really individuated or independent, less are more that is the question. Then you can also define a stationarity index, this is when a given finger is not instructed, how less it moves when it is not instructed, its ability to stay stationary when some other finger is the instructed finger.

The ability of a given finger to continue to stay stationary when it is not the instructed finger, when it is the passive or the non-active or the non-instructed finger that is it is not being affected by the other finger movements. Now let us say for example I am taking the case of the ring finger, how much the ring finger is able to stay stationary when the index finger is the instructor finger or when the middle finger is instructor finger or when the little finger is the instructor finger.

If it is able to stay stationary when these three fingers are the instructed fingers that means that the stationary index for that finger is high. Simply put let us say there are four people in a room. How much let us say I am one of them, let us call myself as w and there is a person x and there is a person y and that is a person z, I am w. Let us say that I am making a statement or I am saying something, how much I am able to influence someone.

When I make a statement the others are simply following, when w is making a statement x, y and z are not independently thinking, they are simply following what I am saying for example. That means that they are not independent, how much independent my own thinking is that is I am saying something, but when I am saying that I am not influencing anybody else, say when w is making a statement x is not influenced by that.

The x is having her own thinking, y is having her own thinking, z is having her own thing or his own thinking. How individuated my thinking is when compared with the others that is individuation index, how much less I am able to influence others, if I am not influencing others to a large extent that means that I am individuated. Now let us consider that x is trying

to say something, how much less either x or y or z is able to influence me is a measure of stationary.

That is I do not influence anybody that is individuation, I am not being influenced by anybody that is stationarity. Think about this, I am not affecting or hurting or influencing or otherwise changing other people's opinion that is individual. No one is able to change my opinion or otherwise hurt me that is stationarity, always try and be stationary. Others are doing something, they are making some noise, you be in your own world that is stationarity.

You are not affected by what the others are doing that is stationarity. You are not affecting others that is individuation. This is of course when a given finger is instructed finger and all the other fingers effects are considered. So it is more of a macro view of finger interdependence. Enslavement matrix on the other hand is a finger to finger interconnection matrix or interdependence matrix, how much the index finger is affecting the middle finger, ring finger, little finger.

How much the middle finger is affecting the index finger, ring finger, little finger. How much the ring finger is affecting index, middle and little. How much little is affecting index, middle and ring this is the enslavement matrix. It is more of a micro measure because I am getting finger to finger relationship. In the individuation index and stationarity index I am getting the measurement with reference to a finger. These are the three measures of finger interdependence are finger enslavement in the kinematic space.

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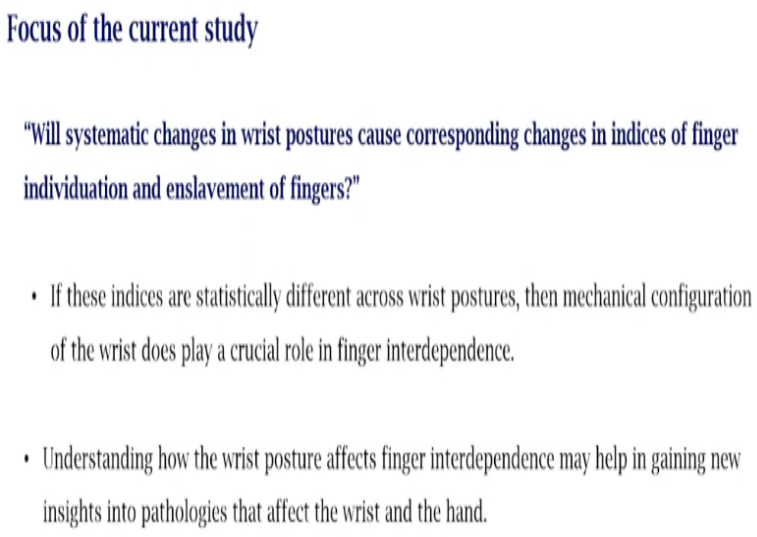

What is the question that we started out with? We asked the question if I make systematic changes in the wrist posture, would it change the indices of finger interaction or finger individuation, enslavement, stationarity? Would these things change depending on wrist posture? What is the expectation? Because if I change the wrist posture there is a change in the mechanical configuration.

The tendons of the four fingers are getting stretched, the tendons that are getting stretched are different depending on whether you are extending or fluxing. Depending on the wrist posture that is whether you are flexed or extended the specific tendons that are getting stretched changes, so it is not necessary that all these tendons have the same effect on all the fingers that is not a very likely situation.

So the hypothesis is that changing the wrist posture systematically will cause a systematic change in the indices of finger interaction such as enslavement, such as individuation index and such as stationarity index. Now if these indices are statistically different between the three postures that means that mechanical configuration of the wrist does play a role in finger interdependence. Now suppose these indices are not statistically different.

Maybe the mechanical configuration of the wrist does not place such a big role in enslavement or finger interdependence on indices of finger interaction. Now we need to understand how this wrist posture affects finger interdependence because it might help us in gaining more insights or more understanding of the pathologies that affect the hand, how we can come up with the approaches to rehabilitate or to treat, provide appropriate therapy that might be dependent on how the fingers respond to different postures of the wrist.

So it is crucial or it is critical for us to have some idea of how the wrist posture affects the indices of finger interaction. So the working hypothesis is that if we change the wrist posture, it will cause a change in the indices of finger interactions that is as we look at different postures we expect to see a statistically different individuation index, stationarity index and enslavement matrix, this was the expectation. We will stop here for this video.

So in this video, we looked at the background for the study on the kinematic enslavement or how wrist posture affects the indices of finger interaction in kinematics. These indices are

individuation index, stationarity index and the enslavement matrix. With this we come to the end of this video. Thank you very much for your attention.