Biomechanics
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Lecture - 73
Wrist Posture and Finger Interdependence - 2

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(FL) Welcome to this video on biomechanics. We have been looking at finger enslavement and whether mechanical configuration of the wrist joint causes a change in the indices of finger interaction. Specifically, we were discussing this paper by Niranjan Chakrabhavi my past dual degrees student who is currently a prime minister's research fellow in Indian Institute of Science and myself, the study performed at IIT Madras.

So in the last video we looked at the background. We said what are these indices of finger interaction. These are individuation index, stationarity index and the enslavement matrix. What is integration index? The ability of a given finger to move independently without affecting other fingers that is individuation. What is stationarity? The ability of a given finger to stay stationary when a different finger is the instructor finger is the stationarity index.

Enslavement matrix defines finger to finger interaction among the four fingers is a 4 by 4 matrix. What was the hypothesis? The hypothesis was that if I make systematic changes in the wrist posture it will cause a statistically different or a systematic change in the individuation index, stationarity index and enslavement matrix, this was the hypothesis. How did we study this? What was the experimental approach that was used? What is the experimental method that was used?

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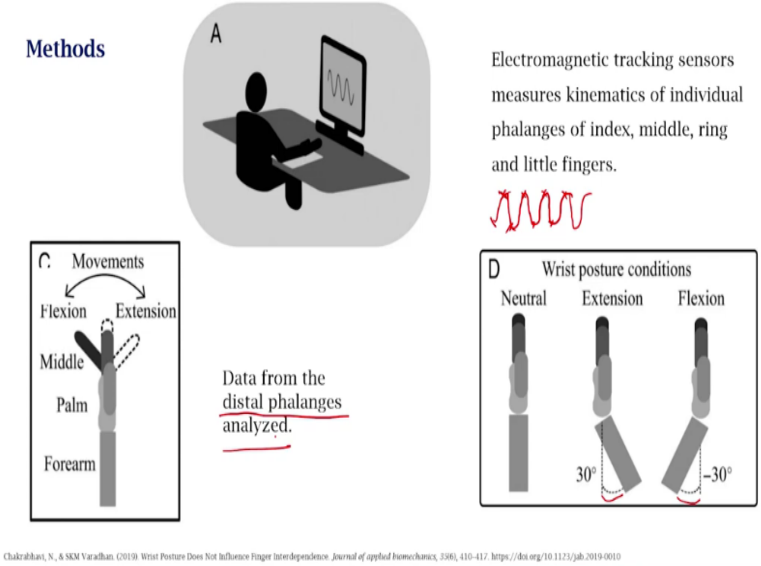

So we placed electromagnetic tracking sensors to measure kinematics of individual phalanges of the index finger, middle finger, ring finger and little finger. So there are three phalanges in each of the finger and we used four of the fingers, so 12 different electromagnetic tracking sensors we placed, using Velcro and surgical tape we placed it. These are really small sensors, the diameter is 1. 8 mm that they can be actually fixed to a finger.

And then we also placed one more sensor on the wrist that is the dorsal side of the palm, so that is a just distal to the wrist joint and we placed one more sensor just proximal to the wrist joint in the forearm. The question that we asked was suppose I keep the hand in this neutral position, the wrist in this neutral position and I make movements with given instructed finger where the instructed finger might be index finger, middle finger, ring finger, little finger like that.

And I am measuring the movements of all the four fingers when each of this take turns to be the instructor finger in the neutral posture or in the flexed posture or in the extended posture. Will the movements of the non-instructed fingers change depending on the posture of the wrist this is the question. So, we measured all the finger movements and all the segmental moments of all the fingers. We measured movements of all the phalanges of all the four fingers involved.

But we informed the participants what was the instructed finger and there were three conditions. First condition is the neutral condition in which the wrist remains neutral, the other condition is when the wrist rest is extended like this and the other condition is when the wrist is flexed like this. So the angle of extension and flexion was 30 degrees. How did we choose this 30 degrees? Because this was an experiment performed in my lab, I know all the details.

It turns out that there was a study performed earlier in Canada using force sensors that also studied the effect of wrist posture on enslavement that used 30 degrees but that is not the reason why we perform this. Actually, what we did? I remember distinctly what happened was that we tried to use 60 degree flexion and 60 degree extension and we performed some pilot studies. It turns out that many of the participants were not able to move their fingers when the wrist was flexed like this.

Movement was very difficult, they felt uncomfortable, they did not want to participate in that experiment. Likewise, when the wrist was extended to 70-80 degrees or 60 degrees they did not really feel comfortable doing the finger moment tasks. Because of this reason we had to choose joint angles that the participants felt were comfortable, within the comfortable range of motion of the participants is where we performed this experiment.

Actually, this can be considered to be a major limitation of the study. I will discuss this in a future video while we are discussing the interpretation, inference and the implications of the study. Right now our focus is to discuss the methods of experimental approach. So we use three different responses; neutral, flexion at 30 degrees and extension at 30 degrees and in each of this we instructed either the index finger or the middle finger or the ring finger or the little finger what was the task.

The task was to follow a metronome and move the instructed finger in a cyclical fashion following the metronome such that for every tick of the metronome you are either at the top or at the trough of the sinusoid. So this is where the tick came and you have to be here, here, here, here and so on and so forth, this was the task. Like this we collected data for 30 seconds which we called as one trial and likewise we collected 3 or 4 trails.

I do not remember the exact details, something like 3 or 4 trials we collected. And to analyze this data we just took the up going half cycle and the downgoing half cycle separately and then we performed analysis of movements of all the fingers. For the purpose of the study we only took the data from the distal phalanges and analyzed, the data from the other segments of the fingers were not analyzed for the purpose of this study.

Because here we are only addressing how the individuation, stationarity and enslavement indices change as a function of wrist posture, for that just the distal phalanges data is enough. Our goal was something else, we were also interested in studying synergies that make up this kind of movements but that was a different study. But in this study, we just restricted our attention to enslavement and so we only focused on the distal phalanges kinematics data.

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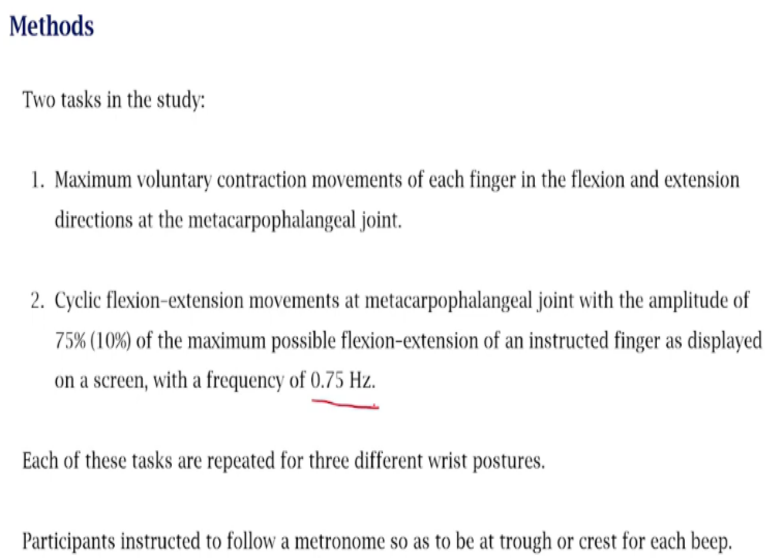

We had two tasks in the study, one is the maximum voluntary contraction moments in which people were asked to make movements maximum flexion and extension movements with each finger. We used this to decide the range of motion of the fingers that will be used in the experimental task. Then cyclic flexion and extension movements at the metacarpophalangeal joint, this is the metacarpophalangeal joint.

Such that 75 percent plus or minus 10 percent of the maximum possible flexion-extension range of motion is achieved with the metronome frequency of 0.75 hertz. This was repeated at the neutral posture, at the flexed wrist posture and at the extended wrist posture. The instruction to the participants was keep up with the metronome, follow a metronome either to be at the trough or at the crest for each beep of the metronome.

That is the movement of one cycle in kinematics was 0.75 hertz, but the metronome frequency was one and a half hertz because we had one beep at the crest and one beep at the trough. So it was a little bit faster than the actual movements, alright.

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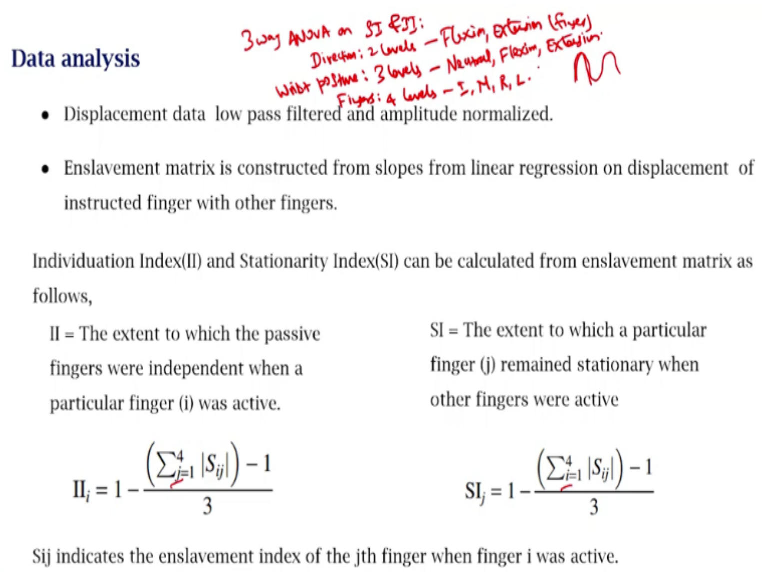

We took the displacement data from the distal phalanges only and we performed a low pass filtering because these movements are very slow, what is the movement 0.75 hertz. So any movement signal that is or any component of the signal that is having high frequency component is likely noise, so we performed a low pass filter at a cutoff frequency less than 5 hertz, actually the cutoff frequency of the low pass filter was 3 hertz.

And we constructed the enslavement matrix by using the slopes of the linear regression on displacement of one finger with the displacement of the other non-instructed fingers. So we constructed the enslavement matrix by performing a linear regression of the instructor finger with the non-instructed fingers and we computed the individuation index and stationarity index as was previously defined by Ross and Schieber.

Similarly, we also computed the II and SI individuation index and stationarity index as the extent to which the passive fingers are independent when a given finger was instructed that is defined as this value. And the extent to which a given finger remains stationary when the other fingers are active is defined using this formula. This was taken from the enslavement where S ij is taken from the enslavement matrix that is the enslavement index of the jth finger when the ith finger was active.

Remember the difference between individuation index and stationarity index. Individuation is how much less I am influencing others, if my own actions do not influence others that means that my actions are individuated. How much less I am affected by other people that is stationarity. If no one cares for me that is individuation or if no one cares about my movements or my actions or my opinions that is individuation, my opinions are completely individual.

If I do not care about anybody, what others are thinking, what others are saying that is stationarity. I hope that is clear. If no one cares about my movements or my actions that is individuation, my actions are then individuated. If I am not affected by what the others are doing or saying that is stationarity, remember the difference that is the difference. And also look at the difference between the formulas for individuation index and stationarity index.

The summation has j here in the formula for individuation index and i here in the formula for stationarity index, this is different, which finger is active that is ith finger. What are all the passive fingers those are all j fingers, remember. The enslavement index of the jth finger when the ith finger is active is S ij, remember. So in which dimension you sum determines whether you are talking about individuation or stationarity, remember.

So it is a little different, it is a very small difference, it is too tiny to be noticed, but the actual difference in the computation is huge, Please be very cautious in understanding and interpreting this. So, we performed statistical analysis on the individuation index and stationarity index and the enslavement matrices. For example, for the individuation index we used a 3-way ANOVA to differentiate between the direction of movement.

Whether your movement is flexing or extending and which half cycle you are, suppose that is what you are doing whether you are in the upcoming half cycle or downgoing half cycle, we separately analyze this, which direction that is. Wrist posture whether it is neutral or flexed or extended because we had three different conditions and which particular fingers were used; index, middle, ring, little.

So 3-way ANOVA on SI and II, what are the three factors? Direction two levels, what are the two levels, flexion extension, flexion extension of the fingers, this is for the fingers, this is movement of the fingers. Then wrist posture, three levels. What are the three levels? Neutral, flexion, extension. Then fingers four levels, what are the four levels? Index, middle, ring, little. Among this of course the four fingers will have different levels of enslavement that is somewhat expected and it has also been previously shown that is not going to be new.

We are also not very keen on exploring direction effects, our most important factor is the wrist posture. Is the wrist posture affecting the II and SI that is the question. Is the neutral flexion and extension wrist postures having different SI and different II in different fingers that is the question that we wanted to ask. And what we found I will discuss in a future video, in the next video, for now we will stop here.

So, in this video we looked at the experimental approach that we took that we used electromagnetic tracking sensors that we placed on all the segments of all the fingers and we only analyzed the data from the distal phalanges and we computed the individuation and stationarity index and we performed the 3-way ANOVA as we just now discussed. With this we come to the end of this video. Thank you very much for your attention.