

Neuroscience of Human Movement
Ministry of Human Resource Development
Indian Institute of Technology, Madras



Lecture - 31
Oligosynaptic and Polysynaptic Reflexes Part 2

So welcome to this class on Oligosynaptic and Polysynaptic Reflexes so this is part 2, I hope of 2 parts.

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In the class...

1. Tonic Stretch reflex
2. Tonic Vibration reflex
3. Interaction among reflex pathways
4. Inter-Joint and Inter-Limb Reflexes



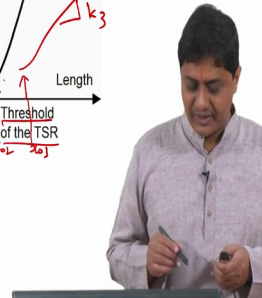
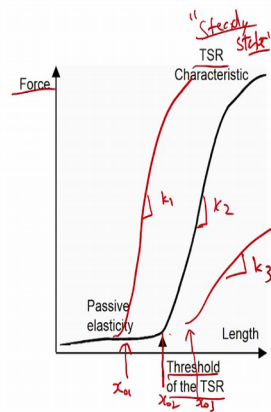
In the previous class we discussed the case of oligosynaptic reflexes 1 a and 1 b and polysynaptic reflexes of Tonic Stretch reflex and Flexor reflex. In this class we will start our discussion with Tonic Stretch reflex and we will discuss other cases, peculiar cases such as Tonic Vibration reflex. And, we will discuss about you know interactions between these pathways and how Inter Joint and Inter Limb Reflexes happen. Because, this is more complicated than say what we have studied so far, what we have studied so far is monosynaptic and disynaptic.

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Tonic Stretch Reflex

A muscle is slowly stretched by an external force. At first muscle resists the stretching due to its passive elasticity. Then, at a certain threshold, recruitment of α -motor neurons begins, leading to an active force development called as tonic stretch reflex. The whole curve is called as tonic stretch reflex characteristic.

T reflex



If a muscle is slowly stretched; so, let us remember what you what do I mean by that; a muscle is stretched, but the rate at which it is stretched is relatively low right. At first the resistance to this stretching is happening due to passive properties. So, that is that the response. Let us remember that the muscle is made of contracted material. So, if I pull the material is going to respond. So, there is a response due to the material properties passive material properties or due to what we call as passive elasticity. Then at some point at some threshold that is going to be a response in terms of recruitment of alpha motor neurons, which actively resist.

Now, let us remind ourselves of the difference between passive resistance and active resistance. Passive resistance is coming from the muscle alone, this will happen even if the muscle is not innervated by a neuron. So, if the muscles is not innervated by a neuron and let us say that it is isolated. Even in that case when I am stretching there is going to be a resistance to that stretch that is offered by the material. This is what we call as passive elasticity.

But when the muscle innervated by a neuron and it is stretched then the neuronal connectivity and shows that there is active. So, when we say active that is going be an influence of alpha motor neurons. So, these alpha motor neurons get recruited and they contract, the muscle is getting stretched and it is you know trying to resist that stretch actively through alpha motor neuronal activation.

So that means, this alpha motor neuronal activation must happen where. So, these alpha motor neurons are located in the spinal cord. So, they must be excited through some means. Somehow they get this leading to what is called as an active force development, this is and this increases the characteristic is there, excuse me the that is the characteristic. This is called as we said as tonic stretch reflex.

The whole curve is called as the tonic stretch reflex characteristic. Let us remind ourselves of what is the phasic part, phasic stretch reflex is the t reflex or the mono synaptic reflexes. As soon as stretch immediately there is a response or the transient response, this response is the steady state response, is it not? This is what we said in the previous class this is the so called steady state response filled up. Now this gives was an impression that and the x axis is length on then the y axis force so; that means, I could come up with a measure similar to stiffness I could find the slope.

The first developed in the spring is proportional to the displacement, where F is the force s is the displacement k is the spring constant to find k I could find, I could do that by finding the slope of the force displacement curve, this is what the we will do mechanical engineers would do is it not. Now, I could find a similar I could find a similar thing that case; and I could come up with a notion or stiffness for this

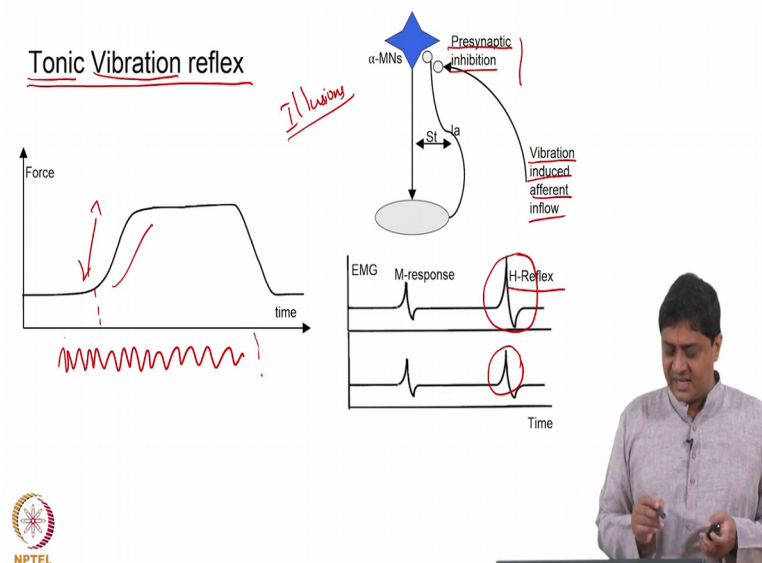
For a long time it was that that muscles are like springs, muscles are behave springs this is a only a approximately true, muscles are viscoelastic, but it is not just that it there are more complications was not shown in this picture is these. Let me let me show what else is there. So, I am going to erase this you know talk about the other things. If the threshold is here for example and the threshold can be at multiple limbs can be modified, you know it could go like that or it go like that. Now, realize that this slope is different from this slope or let us say if the threshold is here it could go like that this one. All these things give rise to you know different case k_1 k_2 k_3 , but not just that.

If you consider this to be and x_0 or the initial resting length of the spring, there are going to be multiple x_0 's I am going to call this as you know x_0^1 x_0^2 x_0^3 etcetera. It seems like this muscle is a spring with multiple resting lengths and with multiple stiffness or in other words is not exactly a spring. Or real spring that we are at least in the in the engineering parlance in spring as an engineering system has air resting length and has air stiffness.

So, here we have a system where a system that behaves like a spring, yet its stiffness seems to vary at multiple levels. And not just that it seems like there are multiple resting lengths. So, this tonic stretch reflex, and the threshold itself can be controlled. So, in other words at what point the force will begin to develop is something that can be controlled by the central nervous system.

Now, that and it is there is a whole theory that talks about how this parameter that is, that is the threshold of the tonic stretch reflex alone can serve as a control parameter for movements ok. We will talk about that in future classes for now it is sufficient for us to know that you know there can be multiple thresholds and there can be multiple slopes. So, it is way more complicated than what we have seen in the previous cases of you know monosynaptic disynaptic reflexes so that is one. So, this is tonic stretch reflex.

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The other case is the case of Tonic Vibration reflex, now in this case suppose I am performing the vibration, and I remove it here. So, this vibration causes a change in the force level that is produced by the muscle. Now this is why does this happen by the way let us look at this terms tonic vibration so tonic. In some sense refers to we said tonic refers to steady state levels. Whereas vibration by definition involves you know high frequency change of something.

These incompatible terms somehow become compatible in the case of the muscle reflex that is produced. If vibration is applied it turns out that the muscles contract and the

produce the force, that is the force that is produced by the way an important difference between other reflexes in the this reflex is that; it is possible for me to suppress this it is the amplitude of this reflex. Or even completely remove this by pure thinking.

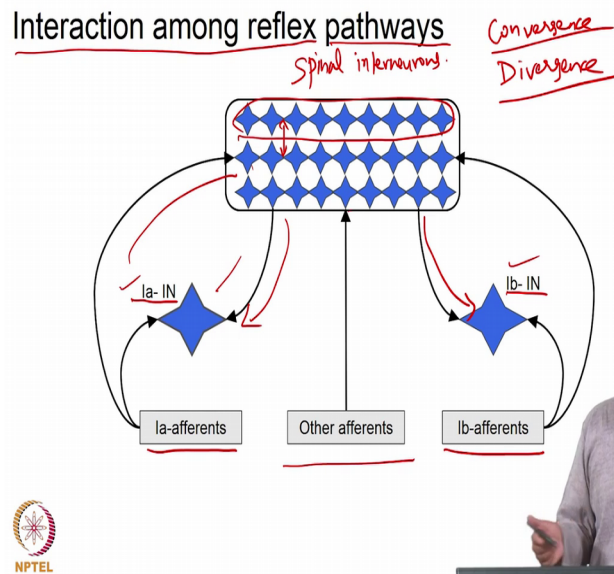
We defined early on long time ago in one of the previous classes that you know reflex is something whose amplitude I cannot control by pure thinking, this is what we defined. And I told that is a working definition that works for that particular context for now. And I told that there will be cases in which it will fail and here is an example of where that definition has failed. I could you know refuse to respond to vibration then there will be no response, an individual can make that choice.

So, it can be suppressed or its amplitude can be reduced or completely attenuated completely removed by pure thinking, what is this mean? This means that; there is a great amount of supraspinal influence on this reflex, supraspinal means; something that is coming from the head. There is an amount of supraspinal influence that could change a way this happens. Now what is what could be the source of this? Well afferents mainly one afferent and other afferents and. So, it is believed that you know the difference is the the behaviour, the change in the behaviour of monosynaptic reflex; that is cause due to vibration. So, what happens is that if there is vibration, the monosynaptic reflex and amplitude changes.

So, here it is something, here it is different that difference is due to vibration itself, but what how is that; what is a mechanism. When people investigated it is widely believed that this is of presynaptic origin. So, that means, the reflex amplitude or the monosynaptic reflex amplitude can be modified by vibrations. There is more actually what other things that could happen illusions; if the person's eyes are closed and you vibrate right? It gives people illusions of you know positions are limb positions that cannot be achieved by anatomical means.

You know for example, hyper extension of the elbow is felt when you vibrate these muscles, when you vibrate the muscles of the upper arm and so on so forth. Several things exist so, but we will briefly we will discuss this here and we will stop here. So, this is the case of tonic vibration reflex.

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Then I discussed earlier that you know; inputs from 1 a interneurons, 1 b interneurons are received they basically send information to multiple interneurons, these are spinal interneurons this can be any number. All this information converges onto these in you know interneurons or to alpha motor neurons. So, as I said earlier in the previous class examination of the spinal cord gives you the impression that you know; it is a complete mess the connections are all completely messy and you cannot make sense out of this. That means, you know our classical neuropsychological approach cannot is not in a position to explain these things.

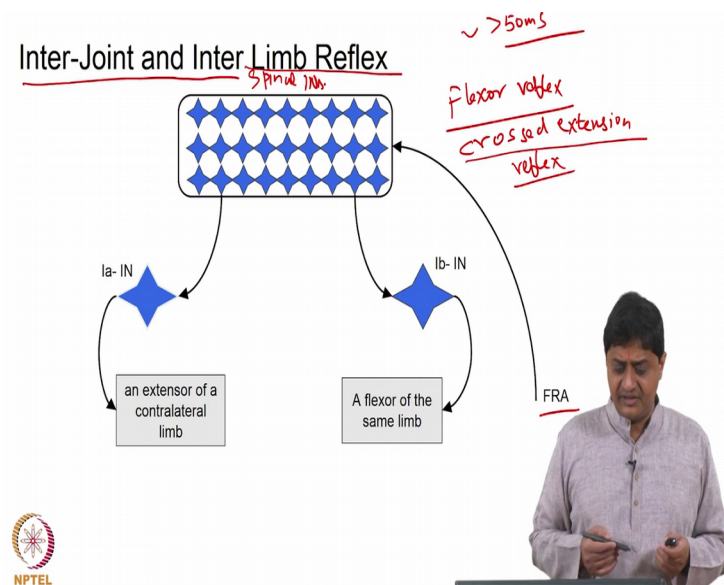
So, that is that is because there are just so many neurons and it is not clear which is connecting to which, what are the connection between these etcetera etcetera. So, that is not work so that is at the level of spinal cord, if that is at the level of spinal cord one has to imagine what will happen at the level of 3, this is at the level of spinal cord, right? So, there is a great amount of interaction among reflex pathways. It is suffices it is sufficient to say that you know.

There is at least convergence and divergence in the reflex pathways both at you know say for example, the 1 a neurons, 1 b neurons and alpha motor neuronal pulls. So, this is going to be a recurring theme in this question, there is convergence; that means, a neuron or a set of neurons receive inputs from multiple sources. So, let us remember 1 a afferents and 1 b afferents are different sources other afferents is a different source.

So, a neuron or a set of neurons can receive inputs from multiple sources. So, information converges that and also information are commands can diverge they can go through two different muscles. Sometimes they can go to you know 2 muscles on 2 sides of the body, which is you know very way because one you know the control pathways are very different. So, it can cross over to the other side. So, the interactions is so great that there is both great amount of convergence and divergence.

And this is also seen at the level of brain which we will discussing in future classes. In future classes while we are discussing a primary motor cortex, while we are discussing cerebellum, while we are discussing the basal ganglia; I will be coming back to this theme of convergence and divergence, but we will try to see where there is convergence and where there is divergence. At least it is sufficient to see that you know inputs from multiple sources when they come to a particular place that is called convergence. And a command from one source if it goes to multiple places that is called divergence both are present in this.

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We discuss the case of the flexor reflex afferents and the flexor reflex. If there is a imminent drencher that is goes to say for example, my right leg. So, flexor reflex afferent detects the presence of say nail or than or something like that right. Then there is going to be flexion of a my right leg withdrawal from the ground right.

When that happens I have to balance my body otherwise I will fall down. I have to balance I have to balance I have to ensure that I do not fall down. For that to happen I have to activate the extensors of the left leg now; that means, there is an inter limb coordination in this case. And usually this is say for example, from if this limb is withdrawn the other limb will you know extend. If the left limb is flexed then the right limb will extend.

So, there is this you know, there is this reciprocal innervation in that sense in some sense. So, this phenomenon; where a flexor is withdrawn is called as flexor reflex which we have seen in that earlier. And extension are relatively concomitance simultaneous extension of the other muscle of the other limb is called as crossed extension reflex. These two happen approximately simultaneously say at the round the same time. So, that the person does not fall down and you know damage are cause injury to his body, so that is important. And these also involves you know several spinal interneurons. Now again one more thing to see is that you know there is also between joint you know coordination that is achieved, which is also similar to the mechanism that is disturb here.

So, there is a reflexes that control other joints, the reflexes that control the contralateral limb the limb on the other side of the body etcetera. These are not monosynaptic. So, when I say reflex, you should not imagine that this is a monosynaptic reflex. These are polysynaptic reflexes the less or greater than 50 milliseconds. So, these are polysynaptic reflexes the response time is going to be that much you should survey for that much time, before the response comes. Otherwise you know if you fall down within that time then you have fallen down. So, basically so the stimulus was strong enough to make you fall down. So, that is the case of inter joint and the inter limb or crossed extensions reflexes.

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Summary

- Tonic Stretch reflex
- Tonic Vibration reflex
- Interaction among reflex pathways
- Inter-Joint and Inter-Limb Reflexes

Polysynaptic

FR
CER

Preprogrammed reaction

NPTEL

So far what we have seen in these classes; the case of tonic stretch reflex and how tonic stretch reflex are the threshold of the tonic stretch reflex can be used as a control parameter. We will discuss this in greater detail in future classes. And tonic vibration reflex and how vibration causes difference in the H reflex amplitude. And interaction among the reflex pathways and there is the case of a inter joint and inter limb reflexes, again both are of polysynaptic origin.

And in the case of flexor reflex and crossed extensor reflex, we have seen this thing. So, coming up next is the topic of pre-programmed reactions. So, what do a what are these are the this consider to be some sort of reflexes are the middle ground between reflexes and voluntary actions. These are triggered reactions whose amplitude and characteristic are already programmed. And just the stimulus presence or absence of the stimulus is sufficient to start the execution of this reaction.

So, this we will see in the next class

Thank you very much.