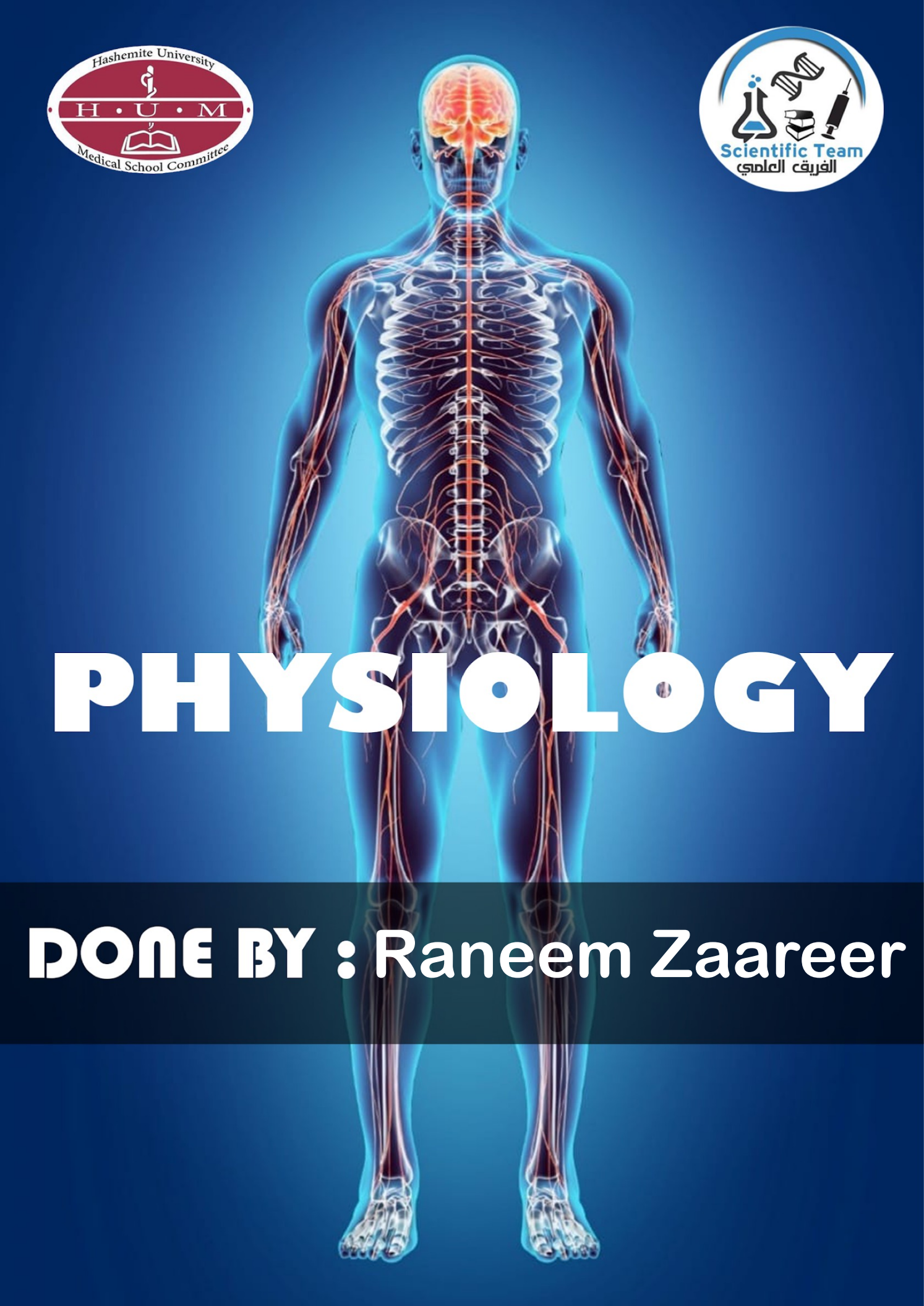

Hashemite University
H · U · M
Medical School Committee
Scientific Team
الفريق العلمي
PHYSIOLOGY
DONE BY : Raneem Zaareer

Human reflexes, Reflex arc, Types of Reflexes.

What is meant by a reflex ?

It is an involuntary stereotypic response to certain stimulus

استجابة احنا ما بنتحكم فيها إنما محفوظة بالجسم يعني الجسم عارف شو ردة الفعل إلي لازم يعملها بعد منبه معين

The reflex arc

-The basic circuit that underlies a reflex:

The Receptor detects the change (stimulus) ---> electrical change ---> action potential along afferent fiber ---> ccentral neurons ---> efferent fiber ---> effector (muscle , gland)

Reflexes :

1- peripheral

2- central :

A- conditioned --> to cerebral cortex – by learning

B- unconditioned : (Hypothalamic, Midbrain, Medullary, Spinal) -- without learning

Handout:

(B) CENTRAL REFLEXES

(I) Conditioned reflexes : These are aquired (develop by learning) and are integrated by the cerebral cortex.

(2) unconditioned: These are inherent (or inborn) i.e. occur without learning. and include (a) Hypothalamic reflexes (regulate many functions e.g. body tempreture and water balance) (b) Midbrain reflexes (mediate postural reflexes and most visual reflexes) (c) Medullary reflexes (mediate cardiovascular, respiratory and

digestive reflexes) (d) Spinal reflexes which include superficial, deep and visceral reflexes.

إحنا رح نحكي بس عن ال spinal

Spinal Reflexes :

According to the number of synapses between afferent + efferent neurons :

1- Monosynaptic: only one synapse, there is no interneuron

المثال الوحيد عليه هو ال stretch reflex

2- Polysynaptic: more than one synapse, there are interneurons

Sensory feedback from muscles :

ال muscles لازم تبعت معلومات لل CNS أول بأول زي ال Muscle tension and length و همه هدول أهم شي وهاي ال sensory feedback رح توصل عن طريق ال reflexes

مثلا كل التغيرات بال muscle length بتوصل ال CNS على شكل stretch reflexes ، التغيرات بال tension .M المسؤول عنها هو inverse stretch reflexes

و كمان ال pain sensation في عنا free nerve endings بتبلغ إنه في pain بعضلة معينة لأنه صار فيها spasm مثلا أو لما تتمرن كتير و يصير في accumulation for lactic acid

Stretch reflex

بداية في عنا capsule (fusiform of connective tissue) داخل ال Fibers .M و بتكون parallel to M. fibers و داخل هاي ال capsule في عنا fibers بنسميهم (intrafusal fibers or muscle spindles)

و طبعا إلي من برا ال capsule هي ال Fibers .M إلي بتكون visible إلنا و بنسميهم extrafusal fibers

Stretch Reflex arc

Stretch :Stimulus

Contraction :Response

ال sensory afferent nerve موصول بال Spindles .M لما يحس إنه صار في stretch رح ينقل المعلومات و يوصل لل DORSAL ROOT OF SPINAL CORD بعدين للcenter of anterior horn و بصير هناك بس synapse واحد فقط ما بين ال efferent N + afferent هاد ال efferent neuron هو نفسه ال alpha motor neuron إلي بغذي و بوصل لنفس هاي ال stretched M و رح يخليها تعمل CONTRACTION

Functional anatomy of the muscle spindle

Parallel arrangement of intrafusal and extrafusal muscle fiber

ال capsule بتكون adherent to the connective tissue of extrafusal muscle fibers و ال tips تاعونها مكملين لعند ال tendons تاعت العضلة

كل intrafusal fiber مقسم لجزئين :

1- central :

هاد ما فيو contractile elements هو بشتغل فقط ك receptive part which detects stretch و يبدأ عنده ال reflex arc stimuli

2- peripheral parts :

هدول الأطراف و همه إلي فيهم ال contractile elements و بصيرلهم contraction بعد ما يوصلهم ال response من ال gama motor fibers مش ال alpha motor لأنه الألفا بتغذي ال extrafusal fibers .M فقط أما هون إحنا عم نحكي عن ال intrafusal fibers

Gama motor neurons بشكلوا تقريبا 30% من ال * anterior horn cells

Innervation (nerve supply) of the muscle spindles

(A) Afferent nerves arising from the spindles

(1) Type Ia nerve fibres : These are type *A* ***alpha fibres*** that are thick (average diameter 17 microns) and rapidly-conducting (velocity of conduction 70-120 meters / second). They arise from the receptor areas of ***both the nuclear bag and nuclear chain muscle fibres,*** where their endings wrap round the fibres forming ***primary*** (= ***annulo-spiral***) ***endings***.

(2) Type II nerve fibres : These are type *A* ***beta fibres*** that are *thinner and slower in conduction* than the Ia fibres (average diameter 8 microns). They arise from ***secondary*** (= ***flower-spray***) ***endings*** at the sides of the primary endings in the ***nuclear chain fibres only***.

(B) Efferent nerves supplying the spindles (gamma efferents)

The peripheral (contractile) parts of the intrafusal fibres are supplied by *thin myelinated* motor nerve fibres called ***gamma efferent nerves*** (= Leksell nerves). These are type *A* ***gamma fibres*** (having diameter 3-6 microns) that are the *axons of small anterior horn cells* called the ***gamma motor neurons*** (figure 36). They form about 30 % of the efferent nerve fibres in the ventral roots (so they are called the ***small motor nerve system***), and are 2 types :

(1) Gamma-d (dynamic) fibres : These supply the ***nuclear bag fibres***, where they end by ***plate endings*** (figure 37).

(2) Gamma-s (static) fibres : These supply the ***nuclear chain fibres***, where they end by ***trail endings*** (figure 37).

** Large *A beta efferent nerves* also supply the intrafusal fibres (figure 37).

Nervous pathway of the stretch reflex

Impulses from the muscle spindles are transmitted to the CNS by its fast-conducting afferent nerve fibres. These proceed ***directly without interven-***

There are two types of intrafusal fibres

i. Nuclear bag fibres

هاي إلي بميزها إنه ال central part عندها بكون dilated معبى nuclei

ii. Nuclear chain fibres

هون ما بكون dilated و بتكون ال nuclei مرتبة كأنها سلسلة مو متجمعة فوق بعضها بال center

There are 2 patterns of stretch :

1- dynamic

2- static

*لو قدامي M. و بلش يصيرلها stretch ، و هو ال stretch قاعد بصير هاي المرحلة بنسميها dynamic pattern و بكون غالبا sudden or risk stretch

*هلأ لو وقف ال stretch عند طول معين يعني ثبت new length و إلي هو مختلف عن ال initial length أو الطول الأصلي للعضلة بنسمي هاد الوضع static pattern

*طيب شو إلي بحدد نوع أو ال pattern of stretch ؟؟؟

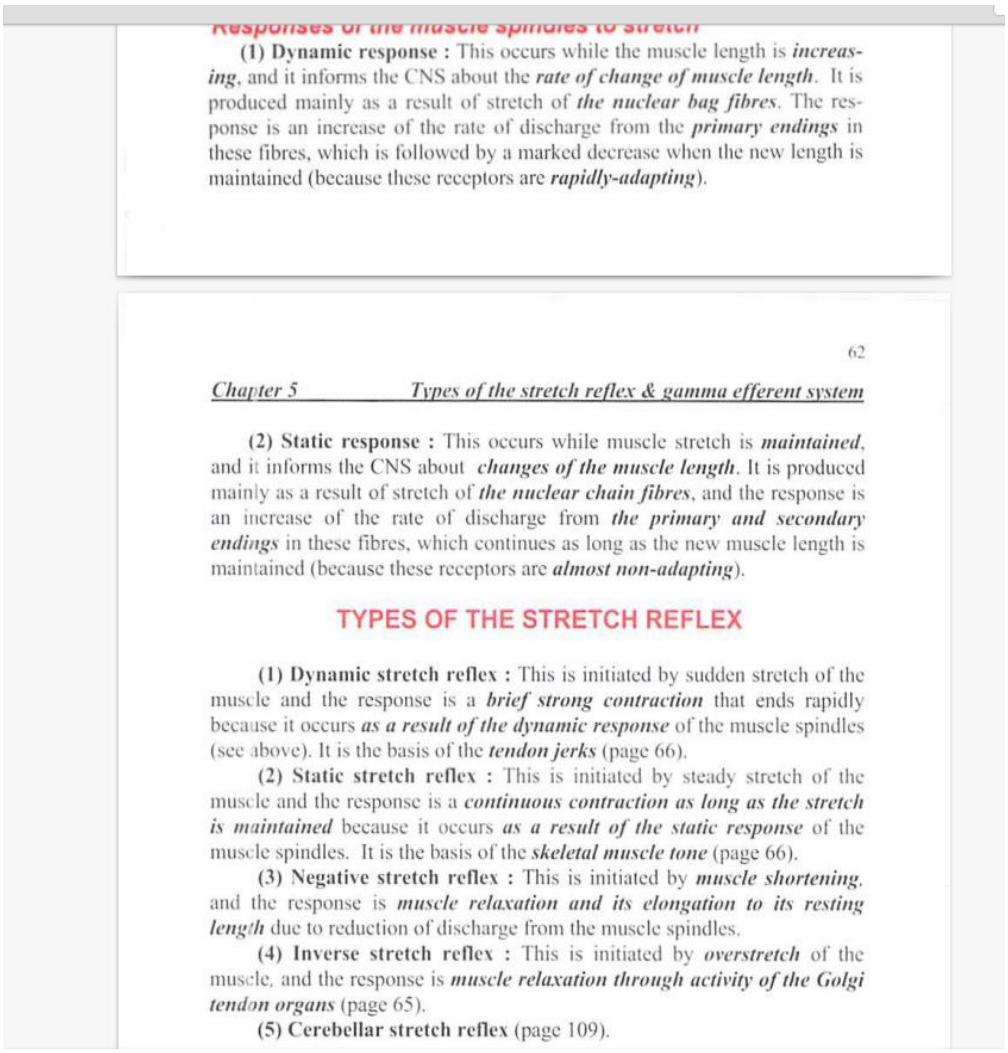
في عنا two systems of receptors in intrafusal fibers بختلفوا عن بعض بال elastic properties , adaptation , nerve supply و كل شكل من أشكال ال stretch

Will be detected by particular form of receptors

*ال dynamic و ال static الهم receptors بال nuclear bag fibers بس بختلفوا بسرعة ال adaptation بحيث أنه ال receptors تاعت ال dynamic هي rapidly adapting recep أما تاعت static هي slowly adapting receptors

في حالة ال nuclear chain fibers فهدول فيهم receptors بس لل static stretch ، يعني في حال صار في dynamic stretch بس ال bag fibers الي رح يصيرلهم stretch أما في حالة ال static فال chain intrafusal fibers + bag رح يصيرلهم stretch

*إشي تاني كل أنواع ال receptors سواء كانت لل static أو ال dynamic فهمه are innervated by type 1a (A alpha) nerves لكن ال chain fibers + static receptors in bag إلهم كمان إضافي بغذيهم إلي هو nerve type 11 (A beta) nerve



Responses of the muscle spindles to stretch

(1) Dynamic response : This occurs while the muscle length is ***increasing***, and it informs the CNS about the ***rate of change of muscle length***. It is produced mainly as a result of stretch of ***the nuclear bag fibres***. The response is an increase of the rate of discharge from the ***primary endings*** in these fibres, which is followed by a marked decrease when the new length is maintained (because these receptors are ***rapidly-adapting***).

(2) Static response : This occurs while muscle stretch is ***maintained***, and it informs the CNS about ***changes of the muscle length***. It is produced mainly as a result of stretch of ***the nuclear chain fibres***, and the response is an increase of the rate of discharge from ***the primary and secondary endings*** in these fibres, which continues as long as the new muscle length is maintained (because these receptors are ***almost non-adapting***).

TYPES OF THE STRETCH REFLEX

(1) Dynamic stretch reflex : This is initiated by sudden stretch of the muscle and the response is a ***brief strong contraction*** that ends rapidly because it occurs ***as a result of the dynamic response*** of the muscle spindles (see above). It is the basis of the ***tendon jerks*** (page 66).

(2) Static stretch reflex : This is initiated by steady stretch of the muscle and the response is a ***continuous contraction as long as the stretch is maintained*** because it occurs ***as a result of the static response*** of the muscle spindles. It is the basis of the ***skeletal muscle tone*** (page 66).

(3) Negative stretch reflex : This is initiated by ***muscle shortening***, and the response is ***muscle relaxation and its elongation to its resting length*** due to reduction of discharge from the muscle spindles.

(4) Inverse stretch reflex : This is initiated by ***overstretch*** of the muscle, and the response is ***muscle relaxation through activity of the Golgi tendon organs*** (page 65).

(5) Cerebellar stretch reflex (page 109).

ال stretch reflex يحصل نتيجة stimulus أو شرارة ، هاي الشرارة هي حاجة من تنين :

1- كل العضلة رح يحصللها stretch

2- فقط ال peripheral contractile parts بصيرلها contraction و بالتالي رح يصير stretch لل central receptive part و إلي رح ينشئ من عنده ال stimulus

بال physical examination عشان يتأكدوا إنه الجهاز العصبي شغال منيح عند هاد المريض بضربوه على ركبته (ضربة خفيفة طبعا) طيب بعد ما يضربوه شو بصير ؟

Sudden stretch of quadriceps M (pattelar tendon) ---> dynamic form of stretch ---> response ---> contraction of quadriceps ---> followed by rapid relaxation

هاد هيك بالوضع الطبيعي لازم يصير

Central connections of the afferent fibres

ال sensory afferent nerve بكون موصول ب 4 أشياء :

1- بدخل ال spinal cord و بعمل synapse with extrafusal efferent fiber عشان يبلش ال reflex arc

2- في إله collateral رح يوصل ال cerebellum و يعمل spinocerebellar tract

3- في collateral تانية رح توصل لل cerebral cortex عشان تزوده بكل المعلومات عن ال changes of muscle length و غيره

4- في collateral رح تروح لل antagonistic M عشان يعمل INHIBITION و هو ما يسمى ال reciprocal innervation

Physiological significance of the stretch reflex

1- Helps to maintain the muscle length.

لو حصل للعضلة stretch طولها رح يزيد أكتر من ال homeostatic value تاعها لكن لما يحصل ال reflex و يصير contraction رح ترجع تقصر و يرجع طولها طبيعي لل initial length

2-Muscle tone

Def: Muscle tone is continuous, alternating, reflex, subtetanic contraction of muscle fibres.

–It may also defined as the resistance of the muscle to stretch.

–Base of muscle tone: Static stretch reflex

كل عضلات الجسم في حالة دائمة من ال contraction (sustained stretch reflex) و هاد المسؤول عن ما يسمى ال tone .M و هي إنه العضلة بتكون resistant لأي حركة ممكن تصير

يعني مثلا لو حاولت أعمل passive extension or flexion لعضلة معينة رح أحس بالبداية بنوع من ال resistance ..... و هاد الإشي طبعا مثال على ال static pattern of stretch

نيجي هلأ نوضح تعريف ال M. Tone بشكل مفصل :

Alternating ---> يعني العضلة ما بتشغل كل ال fibers فيها مع بعض إنما وحدة وحدة تعبت وحدة معينة بنتقل الشغل لوحدة تانية بنفس هاي العضلة (طبعا وحدة قصدي عن ال motor unit)

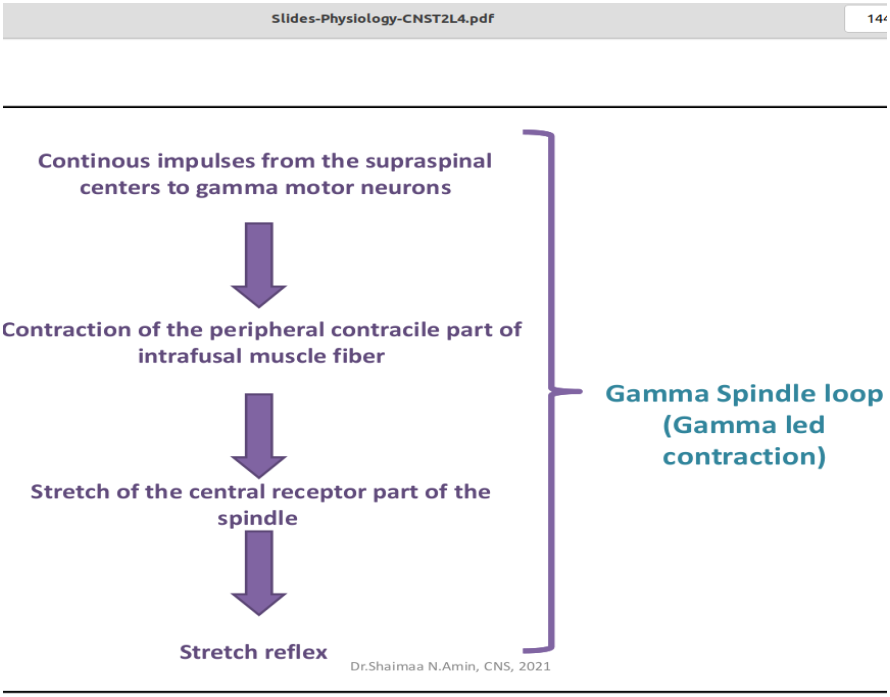
Subtetanic---> يعني ما بتعمل maximum contraction إنما انقباض خفيف عشان بس نحافظ على ال tone

Continuous---> During rest the muscle spindle is continuously stretched, why?

1- gravity : في عضلات تعتبر antigravity و بكون عندهم ال tone أعلى شوي

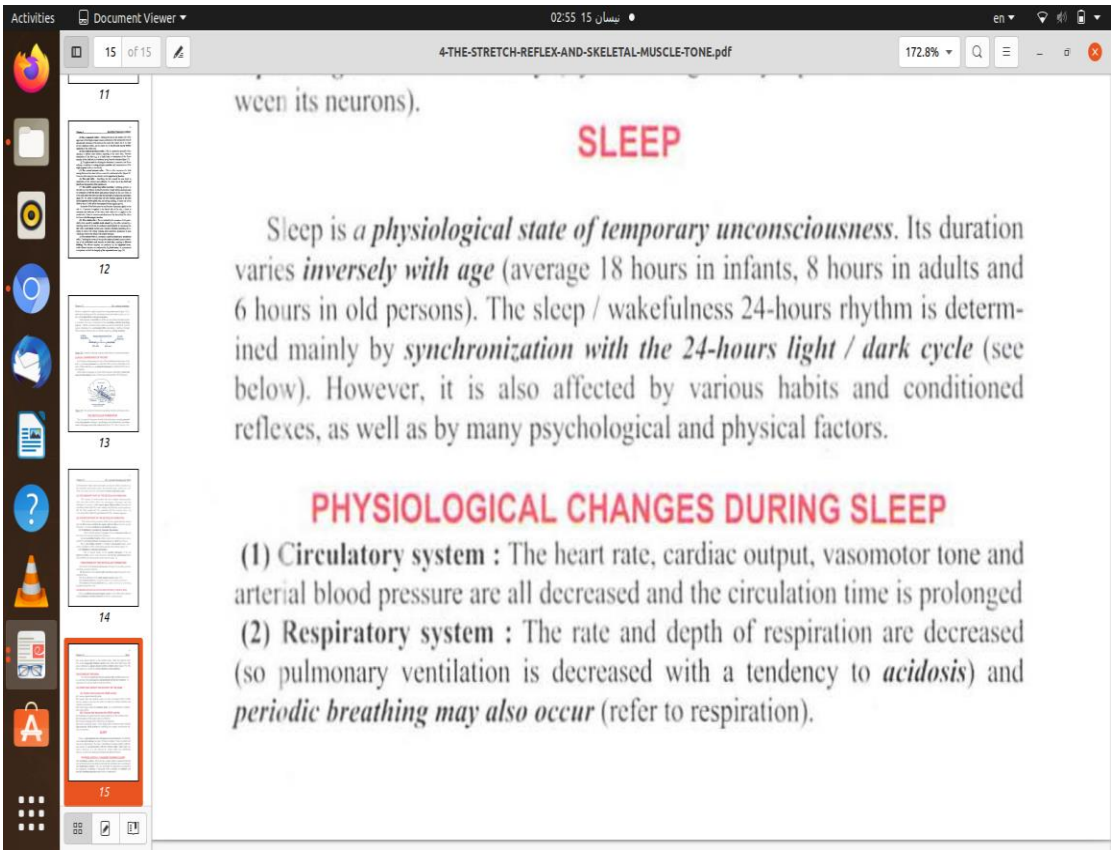
2- anatomically : العضلة بتكون inserted يطريقة بتخليها في حالة من ال stretch

3- المخطط هاد



طب يلا نعرف ليش الواحد بنام ؟

Inhibition of supraspinal centers ---> M. tone decreses in antigravity muscles ---> sleep



Muscle tone does not cause fatigue ?

لأنها alternating and subtetanic وكمان تركيبة ال antigravity fibers ما بيحصللها fatigue

و أنا شرحت معانيهم فوق

Structure of the muscle spindle

Muscle spindles are fusiform stretch receptors present in the ***fleshy parts of skeletal muscles parallel to the muscle fibres*** which are called ***extrafusal fibres*** (figure 36). Each spindle consists of several small muscle fibres called ***intrafusal fibres*** enclosed in a connective tissue capsule that is attached to the sides of the extrafusal fibres. The ***central parts of these fibres are non-contractile*** and constitute the receptor areas of the spindles. On the other hand, their ***peripheral parts are contractile and when they contract, they stretch the central receptor areas***. There are 2 types of intrafusal muscle fibres, which are the following (figure 37) :

(1) Nuclear bag fibres : These have a ***dilated central area*** filled with nuclei and there are typically 2 of these fibres per spindle.

(2) Nuclear chain fibres : These also have multiple nuclei but they are arranged as a ***chain in the receptor area***. They are attached to the sides of the other type, and there are 4-8 of these fibres per spindle.

Nervous pathway of the stretch reflex

Impulses from the muscle spindles are transmitted to the CNS by its fast-conducting afferent nerve fibres. These proceed ***directly without intervening interneurons*** to the ventral horns (figure 36) where they excite the ***alpha motor neurons*** that supply the stretched muscle (by releasing ***glutamate***). Impulses are then transmitted by the alpha motor neurons to the stretched muscle leading to contraction of its extrafusal fibres.

Therefore, the stretch reflex arc contains only ***one synapse***, and it is ***probably the only monosynaptic reflex*** in the body. Its ***reaction time*** (***or total reflex time***) is short (*19- 24 milliseconds*) and its central delay does not exceed *0.9 millisecond* (proving that it is monosynaptic).

Mechanism of stimulation of the muscle spindles

The adequate stimulus for excitation of the muscle spindles is ***stretch***, and this can be produced by either ***passive stretch of the whole muscle*** or stimulation of the ***gamma efferent fibres***. The latter cause contraction of the peripheral parts of the intrafusal fibres, which stretches their central parts and the resulting muscle contraction is said to occur via a **gamma-spindle loop**.

Function of the muscle spindles

The muscle spindles constitute a feedback mechanism that ***maintains the muscle length constant***. Elongation (stretch) of the muscle excites the muscle spindles, which leads to contraction and shortening of the muscle. On the other hand, if the muscle is shortened, the discharge of the muscle spindles decreases, which leads to relaxation and elongation of the muscle. The latter response is sometimes called ***negative stretch reflex*** (see below).

THE GAMMA EFFERENT SYSTEM

FUNCTIONS OF THE GAMMA EFFERENT NERVES

Stimulation of these nerves leads to stretch of the central parts of the muscle spindles, which *increases the sensitivity of the muscles to stretch and may result in reflex muscle contraction.*

CONTROL OF GAMMA EFFERENT DISCHARGE

The gamma motor neurons are controlled by signals discharged from :
(1) Certain supraspinal areas (page 71) **:** These discharge *facilitatory and inhibitory signals through the descending tracts* (figure 36). Such discharge adjusts the stretch reflex in skeletal muscles, which is important for appropriate control of movements and posture. Also, ***anxiety is often associated with increased gamma efferent discharge*** (by supraspinal facilitatory signals), which causes exaggerated tendon jerks in anxious persons (page 69)..

(2) The skin : Noxious stimulation of the skin increases the gamma efferent discharge to the flexor muscles, which potentiates the withdrawal reflex.
(3) The skeletal muscles : Signals from skeletal muscles also increase the gamma efferent discharge as shown in the ***Jendrassik maneuver*** (page 68).

Alpha gamma linkage (or coactivation)

Whenever the alpha motor neurons are activated (whether by supraspinal signals or by impulses discharged from skeletal muscles) the gamma motor neurons are activated at the same time. The ***role of gamma efferent coactivation is to prevent relaxation of the muscle spindles during extrafusal muscle contraction, and to maintain them capable of adjusting the alpha motor neuron discharge throughout the movement.***

(B) CENTRAL REFLEXES

(1) **Conditioned reflexes :** These are acquired (i.e. develop by learning) and are integrated in the cerebral cortex.

(2) **Unconditioned reflexes :** These are inherent (or inborn) i.e. occur without learning, and include **(a)** ***Hypothalamic reflexes*** (regulate many functions e.g. body temperature and water balance) **(b)** ***Midbrain reflexes*** (mediate postural reflexes and most visual reflexes) **(c)** ***Medullary reflexes*** (mediate cardiovascular, respiratory and digestive reflexes) **(d)** ***Spinal reflexes*** which include **superficial, deep and visceral reflexes.**

The following table shows the differences between the static and dynamic types of the stretch reflex :

	DYNAMIC STRETCH REFLEX	STATIC STRETCH REFLEX
Stimulus	Sudden stretch (by tapping on tendons)	Maintained stretch (e.g. by gravity)
Afferent	Type Ia fibres	Type II fibres
Response	Brisk contraction and rapid relaxation	Maintained smooth contraction
Function	Has clinical significance only	Production of muscle tone
Adaptation	Rapidly-adapting	Slowly-adapting
Fatiguability	Rapidly-fatigued	Slowly-fatigued
Enhancement	Enhanced by Jendrassik's and similar maneuver	Not affected by Jendrassik's and similar maneuvers
Existence	only elicited clinically (by a hammer)	exists normally in all muscles specially antigravity muscles

HIGHER CONTROL OF THE STRETCH REFLEX

(A) SUPRASPINAL FACILITATORY AREAS

FUNCTIONS OF THE STRETCH REFLEX

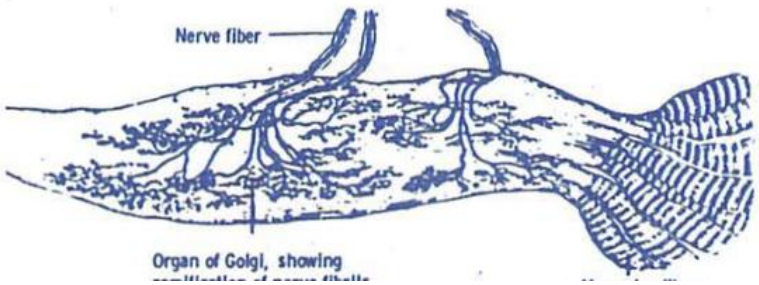
(1) Maintenance of the erect posture against the force of gravity : This occurs through producing a ***strong muscle tone in the antigravity muscles***.

(2) Damping (smoothing) function : The signals discharged to a muscle usually have varying intensities, and this would result in incoordinated movements. However, the signals are adjusted through the *alpha-gamma linkage* so that smooth movements are produced (= ***signal averaging***).

(3) Increasing the power of muscle contraction : As a result of the *alpha-gamma linkage*, both the extrafusal and intrafusal fibres contract when a muscle is stimulated. The intrafusal fibres elicit a stretch reflex by the ***gamma-spindle loop mechanism*** (page 61), which results in a more powerful contraction of the extrafusal fibres (= **servo-assist function**).

H REFLEX (= HOFFMANN'S REFLEX)

This is a ***stretch reflex that is produced experimentally*** by electric stimulation of the Ia afferent fibres from a muscle. It is usually elicited by electric stimulation of the popliteal nerve, and the response is recorded from the calf muscles by the electromyograph.



4-THE-STRETCH-REFLEX-AND-SKELETAL-MUSCLE-TONE.pdf

THE SKELETAL MUSCLE TONE

DEFINITION

The skeletal muscle tone is a state of continuous mild or partial (or subtetanic) contraction of skeletal muscles ***during rest***.

MECHANISM

It is a ***static type of the stretch reflex*** (page 63) that is produced as a result of continuous mild stretch of skeletal muscles during rest by the ***series elastic elements*** present in the tendons (refer to muscle and nerve)..

DISTRIBUTION

It is present in *all skeletal muscles*, but specially in the ***antigravity muscles*** (because they are subjected to more stretch by the force of gravity). These muscles include **(1)** ***Extensors of the lower limbs*** **(2)** ***Flexors of the upper limbs*** **(3)** The ***muscles of the back and back of neck*** **(4)** The ***elevators of the lower jaw***.

FUNCTIONS OF THE SKELETAL MUSCLE TONE

(1) It is essential for maintenance of the ***erect posture***.

(2) It helps both the ***venous return and lymph flow*** from the lower limbs (against the force of gravity).

(3) The abdominal muscles' tone ***prevents visceral ptosis***.

(4) It is **an** ***important source of heat production***, so it is markedly increased on exposure to cold (refer to energy metabolism).

THE TENDON JERKS (TENDON REFLEXES)

A tendon jerk is the response of a skeletal muscle to sudden stretch produced by tapping its tendon ***sharply and strongly by a medical hammer***

الأشياء إلي شرحتها الدكتورة من الهانداوت حطيتلكم إياها و الأشياء إلي ما حكت عنها أبدا ما شملتها بالتلخيص الله بعينكم ارجعولها لحالكم أو ممكن الدكتورة تشرحهم يالمحاضرات الجاية

Raneem Zaareer： Done by