**LAS HORMONAS Y EL DEPORTE**

1. **Introducción**

Los principales estímulos nerviosos para la descarga de las hormonas de liberación son la **ansiedad**, el **estrés** y la **actividad** **física**.

El ejercicio físico es la respuesta desencadenada de un impulso consciente de la corteza cerebral. El ejercicio físico se realiza de forma voluntaria, tras un pensamiento que pasa por el neocórtex cerebral, este comienza a mandar órdenes a los centros de control del movimiento y a los centros del metabolismo, cerebelo y núcleos del tronco del encéfalo y tálamo respectivamente. Una vez iniciado el ejercicio, estos núcleos mandan órdenes a sus dianas (músculos, vasos y órganos) para mantener al sistema en el ritmo de estrés que exige la corteza. Cuando la corteza decide continuar con el ejercicio, aumentar su intensidad o pararlo, el cerebelo, el tálamo y los núcleos del tronco modulan su respuesta.

A nivel hormonal, es el tálamo el mayor regulador que posee el sistema. Una vez comenzado el ejercicio el tálamo estimula los centros nerviosos del hipotálamo y estos secretan los factores hipotalámicos de liberación hormonal de la hipófisis (formando así el eje tálamo-hipotálamo-hipofisario). En nuestro trabajo hablaremos de las hormonas, las cuales ven afectadas su liberación o formación, moduladas por el ejercicio.

Pasaremos a ver como el ejercicio físico regula la fabricación y liberación de las hormonas más importantes (aparte de GH y Testosterona que veremos más tarde):

**ACTH:** regula la producción hormonal de la corteza suprarrenal. La ACTH aumenta directamente la **movilización de triglicéridos** por el tejido adiposo, **aumenta** el **ritmo de la gluconeogénesis** y estimula el **catabolismo de las proteínas**. Las [ACTH] se elevan con la duración del ejercicio si la intensidad supera el 25% de la capacidad aeróbica. El entrenamiento eleva las concentraciones de ACTH durante la actividad física. El aumento de la oxidación de los ácidos grasos conserva el glucógeno, lo que beneficia el rendimiento del ejercicio prolongado.

**Hormonas tiroideas:** durante el ejercicio aumenta la [T4] no unida a proteínas en sangre, lo que puede deberse a los aumentos de la Tª interna con el ejercicio que alteran la unión a proteínas de varias hormonas, entre ellas la T4. Se desconoce la importancia de estas alteraciones transitorias en las concentraciones hormonales. El MB y la temperatura interna en reposo no cambian con el entrenamiento, lo cual indica que el aumento del recambio de la T4 que acompaña al ejercicio regular es consecuencia de un mecanismo diferente al de la dinámica normal de esta hormona.

**Insulina:** la [insulina] disminuye progresivamente durante el ejercicio de intensidad y duración crecientes debido a los efectos inhibidores sobre el páncreas del aumento de la liberación de catecolaminas. La reducción de la insulina potencia la producción hepática de glucosa y sensibiliza al hígado para los efectos de liberación de glucosa del glucagón y la A. Los ácidos grasos proporcionan progresivamente más energía al descender la producción de insulina durante el ejercicio de mayor duración (>1 hora).

1. **Testosterona**

La acción de la Te afecta al metabolismo con efectos anabólicos (aumentar la masa ósea y muscular y su fuerza) y al sexo con efectos androgénicos (maduración de los órganos sexuales y desarrollo de los caracteres sexuales secundarios). **Estos efectos varían según la edad** (el incremento de la edad reduce los niveles de Te). **Durante el desarrollo embrionario** la Te fetal es imprescindible para el desarrollo de la masculinización.

La testosterona estimula el rendimiento atlético por sus efectos anabólicos a largo plazo. Por eso, es una sustancia prohibida en los deportes de competición. Sin embargo, es muy complicado establecer límites para su consumo en competición.

La testosterona incrementa la fuerza máxima y la potencia de las piernas, pero no afecta a la fatiga. Estos cambios son dosis-dependientes. Los efectos de la testosterona a dosis fisiológicas son más notables cuando se combina con el ejercicio.

Se ha demostrado que la administración de testosterona incrementa la masa muscular y la fuerza, más en hombres mayores. Sin embargo, a largo plazo tiene efectos adversos sobre los problemas cardiovasculares.

1. **Testosterona prenatal y radio D2:D4**

La longitud relativa entre el segundo y cuarto dedo (D2:D4) está negativamente relacionada con los niveles de testosterona prenatal y positivamente relacionada con los niveles de estrógenos prenatales. Parece que una gran cantidad de testosterona prenatal y poco estrógeno prenatal se relacionan con el rendimiento deportivo, es decir, que una baja relación D2:D4 de la mano derecha (gran cantidad de testosterona prenatal y baja cantidad de estrógeno prenatal) está relacionada con una gran habilidad en el deporte.

En los hombres, el dedo índice es más corto que el anular, pero en las mujeres sucede al contrario. El mecanismo de desarrollo del dimorfismo sexual en los dedos sigue siendo desconocido, aunque se han hecho estudios en los que se ha visto que hay AR (receptores androgénicos) y ER (receptores de estrógenos) en los dedos de machos y hembras en mayor concentración en 4D. En machos, los dedos están expuestos a ↑[andrógenos] y pocos niveles de estrógenos circulantes, lo que da lugar a una gran actividad de AR y la baja de ER en machos, lo que lleva a los perfiles de expresión génica diferencial en 4D con respecto a 2D. A su vez, la proliferación de condrocitos se incrementa en la falange proximal del 4D, lo que resulta en una elongación del 4D con respecto al 2D. En hembras sucede lo contrario.

En general, los hombres tienen mejor visión espacial que las mujeres. Se ha visto que existe una relación inversa entre el radio D2:D4 y la visión espacial. Esto sugiere que la exposición prenatal a testosterona influye en el desarrollo del cerebro llevando a un mejor rendimiento en la visión espacial de los hombres.

La baja relación D2:D4 está asociada con una máxima captación de oxígeno. También parece que la testosterona prenatal tiene efectos en la fuerza del hombre. Por lo tanto, esta baja relación D2:D4 está relacionada con el rendimiento y éxito en el deporte. Así que se podría utilizar el D2:D4 como un predictor del éxito deportivo.

1. **Hormona de crecimiento (GH)**

Se sintetiza en las **células somatotrópicas**. Los pulsos son máximos durante el **desarrollo puberal** y disminuyen a partir de los 20 años. La **estimulación** de la secreción de GH viene determinada por la **GHRH**. La **inhibición** viene determinada por la secreción de **SS** o GIH. La mayoría de estas acciones las realiza junto con **IGF-1** o **somatomedina C**.

**GH-IGF-1: acciones sobre el metabolismo: 1-**La **GH** provoca **hiperglucemia. 2-**Estimula **lipólisis** (**incremento de AGL** en el plasma). **3-**En hígado, estimula la **síntesis de proteínas**, la **gluconeogénesis**, **síntesis de somatomedinas y** **disminuye el colesterol circulante**. **4-**En músculo, **disminuye la captación de glucosa**, **incrementa la captación de aa** y estimula **síntesis de proteínas** **e IGF-1**.

Estas acciones metabólicas **dependen del estado nutricional** del sujeto: 1-Una **dieta normal**, estimula la secreción. 2-Las **dietas ricas en glúcidos** no favorecen la liberación de GH. 3-Las **dietas ricas en proteínas** incrementan la secreción. 4-En **situación de ayuno** se incrementa la secreción sin efectos sobre el crecimiento por la falta de insulina.

Niveles altos mantenidos de GH pueden llevar a una **diabetes** debido a su efecto antiinsulínico y al efecto estimulador sobre la secreción de insulina (agotamiento de la misma).

En definitiva, de sus acciones en el crecimiento y en el metabolismo son **incrementan la masa magra** y **disminuyen la grasa corporal** y **aumentan la tasa metabólica** y **disminuyen el colesterol circulante**. Además, **crecimiento general del esqueleto** y de los tejidos y órganos.

**Grelina** actúa sobre las propias neuronas del arqueado que producen la GHRH e inhibe la secreción de SS. La **insulina** tiene un efecto estimulador sobre la síntesis y secreción de GH.

1. **GH y ejercicio**

El ejercicio es un potente estímulo para la liberación de GH. La magnitud de la liberación de GH con el ejercicio dependerá de varios factores (edad, intensidad, duración). GH es importante en la regulación del metabolismo después del ejercicio. El ejercicio regular intenso en personas mayores incrementa los niveles de GH y testosterona. El eje GH-IGF-1 ejerce efectos metabólicos importantes durante el ejercicio.

La sustitución de GH incrementa la capacidad del ejercicio en personas con **deficiencia** de dicha hormona. El suministro de dosis suprafisiológicas de GH en atletas incrementa los ácidos grasos libres y reduce la oxidación de proteínas, lo que impide la pérdida de masa corporal. A pesar de ello, no se sabe si estos efectos están relacionados con un mejor rendimiento deportivo. Se abusa porque no es detectable, pero está prohibida.

La secreción de GH empieza 15 minutos después del inicio del ejercicio. El suministro de GH en personas mayores y débiles provoca cambios en las proporciones de las fibras musculares y en el diámetro del mismo. Sin embargo, se requieren más estudios para verificarlo.

Existen pocas evidencias de las mejoras en el rendimiento deportivo mediante el suministro de GH en personas sanas y atléticas. En adultos sanos, la GH solo incrementa la masa magra y la capacidad anaeróbica.

1. **El dopaje**

**La Agencia Mundial Antidopaje define el dopaje** o *doping* como: la violación de cualquiera de estas reglas: La presencia de una sustancia prohibida, sus metabolitos o marcadores, en el cuerpo de un atleta, así como el uso, o intento de uso, de una sustancia o método prohibidos. -Hacer trampa, o intentar hacer trampa de cualquier forma durante los controles. -La posesión de sustancias prohibidas o de métodos prohibidos, así como la compraventa o intento de compraventa de sustancias prohibidas o de métodos prohibidos.

Principales Sustancias: Esteroides: Son sustancias que, al influir en la producción de [aminoácidos](http://es.wikipedia.org/wiki/Amino%C3%A1cido), contribuyen al aumento de la masa muscular y de la fuerza, así como de la [agresividad](http://es.wikipedia.org/wiki/Agresividad). Estimulantes, como la [cafeína](http://es.wikipedia.org/wiki/Cafe%C3%ADna) y la [estricnina](http://es.wikipedia.org/wiki/Estricnina), que se utilizan para estar más despierto y demorar la fatiga. Analgésicos narcóticos, para mitigar el dolor y conseguir un efecto tranquilizante. Betabloqueantes, sustancias que disminuyen los latidos del [corazón](http://es.wikipedia.org/wiki/Coraz%C3%B3n) y estabilizan el organismo, por lo que particularmente los usan los [arqueros](http://es.wikipedia.org/wiki/Arquero) y los [tiradores](http://es.wikipedia.org/wiki/Tirador). Diuréticos, para perder peso en poco tiempo y para que, cuando se lleven a cabo las pruebas, no se detecten otras sustancias prohibidas.

**Historia del Dopaje:** el dopaje ha sido una constante en toda la historia del deporte, desde los juegos en Grecia hasta la actualidad. Pero también es interesante saber que ha habido otros casos de dopaje en la historia como en la mitología nórdica, en la América pre-colombina o en las guerras como la II guerra mundial.

**Eritropoyetina:** Para eliminar el proceso del doping sanguíneo, los deportistas de fondo utilizan actualmente la eritropoyetina, una hormona que producen en condiciones de normalidad los riñones. Esta hormona induce la formación de glóbulos rojos por la medula ósea. Desde un punto de vista medico la EPO combate la anemia en los pacientes con enfermedad renal grave. Desgraciadamente su aplicación exógena sin control puede provocar que el hematocrito alcance niveles demasiado altos, esto provoca la condensación de la sangre y eleva la viscosidad de la sangre y a su vez la presión sanguínea. Esto potencia la probabilidad de accidentes cerebro vasculares, ataques cardíacos, IC, embolia pulmonar e incluso la muerte.

**Clembuterol:** El análisis amplio al azar en deportistas de competición acerca del uso de los esteroides anabolizantes ha dado como resultado la aparición de un numero de sustitutos de los esteroides en los alimentos dietéticos ilícitos. Un fármaco de este tipo es la amina simpaticomimética Clembuterol que se ha hecho popular entre los deportistas debido a sus supuestos beneficios de formación de tejidos y reducción de grasa. El Clembuterol pertenece a un grupo de compuestos químicos clasificados como agonistas betaadrenérgicos , no está autorizado para su uso humano en los estados unidos pero se prescribe habitualmente en el extranjero como broncodilatador para tratar los problemas bronco-obstructivos. El Clembuterol facilita la respuesta de los receptores. Una revisión de los estudios animales (no existen estudios humanos) indica que cuando el ganado sedentario recibe Clembuterol en dosificaciones superiores a las recomendadas para tratar el asma bronquial, el Clembuterol eleva la disposición de proteínas en el musculo esquelético y cardíaco y retarda la ganancia de grasa al aumentar la lipólisis. Por lo tanto el Clembuterol también se ha utilizado en estudios para tratar el envejecimiento, la malnutrición, la inmovilización..muscular. Es decir el Clembuterol redujo la proteinolisis y aumento la proteinogénesis.

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# Testosterona

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