Nörofizyolojik Yaklaşımlar

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BÖLÜM 1

NÖROFİZYOLOJİYE GİRİŞ

Gamze AYDOĞAN [1]

GİRİŞ

İnsan vücudunun temel yapı birimi hücredir. Her hücre tipi, organizmanın yaşamını sürdürebilmesi için gerekli olan belirli görevleri yerine getirmek üzere özelleşmiştir. Yapı ve işlev bakımından farklılık gösteren bu hücrelerin tümü, organizmanın yaşamını sürdürebilmesi için gerekli fizyolojik dengeyi koruma amacı taşımaktadır. Bu denge, fizyolojide homeostaz olarak tanımlanır. Homeostaz, organizmanın iç ortamının dış çevrede meydana gelen değişikliklere rağmen belirli sınırlar içinde sabit tutulmasıdır. Vücuttaki tüm sistemler bu dengenin korunmasına katkıda bulunmakla birlikte, sinir sistemi homeostatik mekanizmaların düzenlenmesinde merkezi bir role sahiptir.

SİNİR SİSTEMİNİN TEMEL YAPI VE FONKSİYONLARI

Sinir sistemi, organizmanın iç ve dış çevresinden gelen uyaranları algılayıp analiz eden, bu doğrultuda uygun yanıtları planlayan ve efektör organlar aracılığıyla uygulamaya aktaran gelişmiş bir kontrol mekanizmasıdır. Çevreden ya da vücudun iç ortamından kaynaklanan uyaranlar öncelikle duyusal reseptörler tarafından algılanır ve sinir impulsları şeklinde merkezi sinir sistemine iletilir. Merkezi sinir sistemi, bu bilgileri değerlendirerek uygun yanıtı oluşturur ve motor

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tunu ve sonuç olarak BDNF proteininin sinaptik aralığa salınmasını tetikleyerek sinaptik plastisiteyi ve öğrenmeyi optimize etmektedir (21).

SONUÇ

Sinir sistemi, organizmanın çevresiyle etkileşimini sağlayan ve homeostatik dengeyi sürdüren temel düzenleyici sistemdir. Nöronal iletişim mekanizmalarının, sinaptik organizasyonun ve nöroplastik süreçlerin anlaşılması; nörolojik hastalıkların değerlendirilmesi, rehabilitasyon yaklaşımlarının planlanması ve motor öğrenmenin desteklenmesi açısından büyük önem taşımaktadır. Güncel nörobilim araştırmaları, sinir sisteminin yaşam boyu değişim gösterebilen dinamik bir yapı olduğunu ortaya koymakta ve klinik uygulamalara yeni bakış açıları kazandırmaktadır.

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BÖLÜM 2

MOTOR KONTROL VE HAREKETİN NÖROFİZYOLOJİSİ

Özge BAYKAN ÇOPUROĞLU[1]

GİRİŞ

İnsan hareketi, biyomekanik, nörofizyolojik ve duyusal süreçlerin eş zamanlı ve bütüncül etkileşimi sonucunda ortaya çıkan çok boyutlu bir fenomendir. Hareketin oluşumu yalnızca kasların mekanik kasılma süreçleri ile açıklanamaz; aksine merkezi sinir sistemi (MSS), periferik sinir sistemi (PSS), kas-iskelet sistemi ve duyusal geri bildirim mekanizmalarının dinamik entegrasyonu ile gerçekleşir. Bu bağlamda motor kontrol, organizmanın çevresel taleplere uyum sağlayacak şekilde hareket üretme, düzenleme ve adapte etme kapasitesini ifade eden kapsamlı bir nörofizyolojik süreç olarak tanımlanmaktadır (1,2). Motor kontrol, yalnızca istemli hareketlerin başlatılmasını değil; aynı zamanda postüral stabilitenin korunmasını, denge reaksiyonlarının oluşturulmasını ve motor öğrenme süreçlerinin sürdürülmesini de içermektedir.

Motor kontrol kavramı, tarihsel olarak refleks temelli açıklamalardan başlayarak giderek daha karmaşık teorik modellere doğru evrilmiştir. Erken dönem nörofizyolojik yaklaşımlar, hareketin temel belirleyicisinin spinal refleksler olduğunu öne sürerken, bu görüş zamanla yerini hiyerarşik organizasyon modellerine bırakmıştır. Hiyerarşik modele göre hareket kontrolü, üst merkezlerden alt merkezlere doğru organize edilen bir yapı göstermektedir. Ancak bu model, çevresel etkileri ve duyusal geri bildirimin rolünü yeterince açıklayamamıştır. Günümüzde ise dinamik sistemler yaklaşımı ön plana çıkmakta olup, bu yakla-

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gun motor paternlerin seçilmesinde, serebellum ise hareketin koordinasyonu ve hata düzeltilmesinde temel rol oynamaktadır. Bu üst düzey yapılar, omurilikteki refleks mekanizmalar ve motor nöronlar aracılığıyla kaslara iletilen komutlarla bütünleşerek hareketin gerçekleşmesini sağlar.

Kas fizyolojisi, bu sinirsel komutların mekanik harekete dönüştüğü son aşamayı temsil etmekte olup motor ünite organizasyonu ve kasılma mekanizmaları hareket performansını doğrudan belirlemektedir. Tüm bu bileşenler arasındaki etkileşim, motor kontrolün dinamik ve adaptif bir sistem olduğunu göstermektedir.

Motor kontrol sisteminin bütüncül olarak anlaşılması, özellikle nörolojik hastalıklarda ortaya çıkan hareket bozukluklarının değerlendirilmesi ve etkili rehabilitasyon yaklaşımlarının geliştirilmesi açısından kritik öneme sahiptir. Bu nedenle motor kontrolün nörofizyolojik temelleri, hem temel bilimler hem de klinik uygulamalar açısından vazgeçilmez bir bilgi alanı oluşturmaktadır.

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BÖLÜM 3

DUYUSAL SİSTEMLER VE ALGI

Gamze KILIÇ[1]

Duyusal sistemler, vücudumuzun hem dış çevreden hem de kendi içinden gelen bilgileri algılamasını sağlayan temel yapılardır. Eskiden bu sistemler; görme, işitme, somatosensöriyel, denge (vestibüler) ve koku (olfaktör) gibi ayrı ayrı incelenir ve sadece uyaranları algılayıp beyne ileten pasif yapılar olarak düşünülürdü. Ancak son yıllarda yapılan çalışmalar, algının aslında sadece dışarıdan gelen bilgilerin birebir yansıması olmadığını; daha karmaşık, sürekli değişen ve içinde bulunulan duruma göre şekillenen aktif bir süreç olduğunu göstermektedir (1-3).

Güncel nörobilim çalışmalarına göre algı, artık sadece dış dünyadan gelen duyusal bilgilerin (bottom-up süreçler) beyin tarafından işlenmesi olarak görülmemektedir. Bunun yanında, bireyin geçmiş deneyimleri, beklentileri ve bilişsel durumu gibi üst düzey süreçlerin (top-down) de algıyı önemli ölçüde etkilediği kabul edilmektedir. Özellikle "öngörücü işleme" (predictive processing) modelleri, beynin çevreyle ilgili sürekli tahminler oluşturduğunu ve gelen duyusal bilgileri bu tahminlerle karşılaştırarak anlamlandırdığını öne sürmektedir (4). Bu nedenle algı, dış dünyanın birebir bir kopyası olmaktan ziyade, organizmanın çevreye en iyi şekilde uyum sağlamasına yardımcı olan dinamik ve işlevsel bir süreç olarak değerlendirilmektedir (5).

Bu çerçevede duyusal sistemlerin işleyişini anlamak, algının nasıl oluştuğunu ve çevreyle etkileşimin nasıl düzenlendiğini açıklamak açısından büyük önem taşımaktadır. İnsan organizması; somatosensöriyel sistem, görsel sistem, işitsel sistem, vestibüler sistem ve diğer duyusal yapılar aracılığıyla çevreden gelen bil-

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yaşam aktivitelerinin güvenli ve etkili biçimde sürdürülebilmesi; çevresel uyaranların doğru algılanmasına, duyusal bilgilerin uygun şekilde bütünleştirilmesine ve bu bilgilere uygun motor yanıtların oluşturulmasına bağlıdır.

Duyusal işlemleme yalnızca periferik reseptörlerden gelen bilgilerin beyne iletilmesiyle sınırlı değildir. Beyin, duyusal girdileri dikkat, deneyim, öğrenme, beklenti ve çevresel bağlam doğrultusunda sürekli olarak organize etmekte ve yeniden yorumlamaktadır. Bu nedenle algı; pasif bir kayıt mekanizmasından ziyade, organizmanın çevreye uyumunu destekleyen aktif ve dinamik bir süreç olarak değerlendirilmektedir. Özellikle multisensör entegrasyon mekanizmaları, farklı duyusal kaynaklardan gelen bilgilerin bir araya getirilmesini sağlayarak beden farkındalığı, postüral kontrol, mekânsal yönelim, hareket planlama ve çevresel farkındalığın oluşumuna katkıda bulunmaktadır.

Son yıllarda nörobilim alanında elde edilen bulgular, duyusal sistemlerin yüksek düzeyde nöroplastik özellik gösterdiğini ve deneyimlere bağlı olarak yeniden organize olabildiğini ortaya koymuştur. Bu durum, duyusal sistemlerin yalnızca normal fizyolojik işlevlerin anlaşılması açısından değil; nörolojik hastalıkların değerlendirilmesi, klinik semptomların yorumlanması ve rehabilitasyon yaklaşımlarının geliştirilmesi açısından da önemli olduğunu göstermektedir. Bu nedenle duyusal sistemlerin yapısal organizasyonunun, merkezi işlemleme mekanizmalarının ve duyular arası etkileşimlerin anlaşılması; hem temel nörobilim hem de klinik uygulamalar açısından büyük önem taşımaktadır.

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NÖROLOJİK HASTALIKLARDA NÖROFİZYOLOJİK DEĞİŞİKLİKLER

Nesibe ÇAKMAK [1]

İNME: NÖROFİZYOLOJİK ETKİLER VE REHABİLİTASYON YAKLAŞIMLARI

1. Giriş

İnme, dünya genelinde uzun süreli engelliliğin önde gelen nedenlerinden biri olmaya devam etmektedir ve yetişkinlerde edinilmiş yetersizliklerin temel kaynağıdır. İnmenin sonuçları sadece ilk nörolojik hasarla sınırlı kalmayıp; motor, bilişsel ve duyusal fonksiyonları derinden etkileyen bir dizi nörofizyolojik değişikliği tetikler. Modern rehabilitasyon paradigması, telafi edici stratejilerden ziyade, nöroplastisiteyi ve fonksiyonel restorasyonu aktif olarak teşvik eden müdahalelere doğru evrilmiştir. Bu değişimdeki en büyük pay, fonksiyonel manyetik rezonans görüntüleme (fMRI) ve transkraniyal manyetik stimülasyon (TMS) gibi nörogörüntüleme teknolojilerinin beyindeki reorganizasyonu görselleştirmemize olanak sağlamasıdır (1).

2. İnme Patofizyolojisi

İnme, serebral kan akışının iskemik tıkanma veya hemorajik rüptür yoluyla kesilmesi sonucu nöronal ölüm ve doku hasarı ile karakterizedir. Akut fazda; eksitotoksisite, oksidatif stres, inflamasyon ve apoptoz süreçleri iskemik çekirdek ve çevresindeki penumbra bölgesinde yıkıma neden olur.

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NÖROFİZYOLOJİK YAKLAŞIMLARDA DEĞERLENDİRME

Ebru SEVER [1]

GİRİŞ

Nörofizyolojik yaklaşımlar, inme geçiren bireylerde hareket kontrolünün yeniden kazanılmasını, bağımsızlık düzeyinin artırılmasını ve bireyin günlük yaşam ile sosyal çevresine daha etkin katılımını destekleyen rehabilitasyon yaklaşımlarının önemli bir bileşenidir. Bu yaklaşımlarda değerlendirme süreci, yalnızca bireydeki bozuklukların tanımlanmasına yönelik bir basamak olarak görülmemelidir. Değerlendirme; tedavi amaçlarının belirlenmesi, bireyin gereksinimlerine uygun müdahale stratejilerinin planlanması ve rehabilitasyon sürecindeki ilerlemenin izlenmesi açısından klinik karar verme sürecine yön veren dinamik bir yapıdadır. Bu nedenle değerlendirme, yalnızca nöromüsküler yetersizlikleri ortaya koyan bir inceleme yerine; bireyin fonksiyonel kapasitesini, günlük yaşam aktivitelerindeki bağımsızlık düzeyini ve sosyal yaşama katılımını birlikte ele alan bütüncül bir süreç olarak planlanmalıdır. Bu bakış açısı, klinisyenin yalnızca bozukluğun türünü ve şiddetini belirlemesini değil, aynı zamanda bu bozukluğun bireyin günlük yaşam performansı, bağımsızlığı ve katılım düzeyi üzerindeki etkilerini de anlamasını sağlar (1,2).

Nörofizyolojik Yaklaşımlarda Değerlendirme ve ICF Temelli Yaklaşım

Uluslararası İşlevsellik, Yetiyitimi ve Sağlığın Sınıflandırılması (International Classification of Functioning, Disability and Health; ICF), bireyin sağlık durumunu yalnızca hastalık ya da tanı temelinde değerlendiren bir yaklaşım sun-

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SONUÇ

Nörofizyolojik yaklaşımlarda değerlendirme süreci, yalnızca motor bozuklukların ya da nöromüsküler yetersizliklerin belirlenmesiyle sınırlı değildir. Bobath, Brunnstrom ve Margaret Johnstone yaklaşımlarında değerlendirme; bireyin hareket kalitesi, motor iyileşme evresi, tonus durumu, duyusal bütünlüğü, günlük yaşam aktivitelerindeki bağımsızlığı ve sosyal katılım düzeyi dikkate alınarak bütüncül biçimde ele alınmalıdır. ICF temelli değerlendirme çerçevesi, klinisyene bireyin vücut fonksiyonları, aktivite, katılım, çevresel ve kişisel faktörlerini birlikte analiz etme olanağı sağlar. Bu nedenle standart ölçekler, klinik gözlem ve fonksiyonel analiz birlikte kullanılarak bireye özgü, hedef odaklı ve etkili bir rehabilitasyon programı planlanmalıdır.

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NÖROFİZYOTERAPİDE TEDAVİ YAKLAŞIMLARI

Tansu KUŞ [1]

GİRİŞ

Nörofizyoterapide tedavi yaklaşımları, nörolojik hastalıklara bağlı olarak ortaya çıkan motor, duyusal ve fonksiyonel problemlerin tedavisinde kullanılan çeşitli yöntemleri kapsamaktadır. Bu yaklaşımlar, benzer şekilde nöroplastisite ve motor öğrenme gibi temel nörofizyolojik mekanizmalara dayanarak rehabilitasyon sürecinde önemli bir yer tutmaktadır. Bu bölümde Bobath konsepti, propriyoseptif nöromüsküler fasilitasyon (PNF), motor öğrenme prensipleri, robotik rehabilitasyon ve transkraniyal manyetik stimülasyon (TMS) tedavi yaklaşımları ele alınmaktadır.

1. BOBATH KONSEPTİ

Başlangıcı 1940'lı yıllara dayanan, Berta ve Karel Bobath tarafından geliştirilen Bobath konsepti, nörolojik rehabilitasyonda yaygın kullanılan nörofizyolojik yaklaşımlardan biridir (1). İlk olarak, ''anormal refleks aktivitesinin inhibisyonuna ve normal hareketin kolaylaştırılması yoluyla yeniden öğrenmeye dayalı bir tedavi konsepti" şeklinde tanımlanmıştır (2). Günümüzde ise, merkezi sinir sistemi (MSS) lezyonu nedeniyle hareket, postüral kontrol ve fonksiyon bozukluğuna sahip bireylerin değerlendirme ve tedavisinde bir problem çözme yaklaşımı olarak tanımlanmaktadır (3).

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iyileştirmede etkili olduğunu ortaya koymuştur (123, 124).

rTMS'nin motor fonksiyon üzerindeki etkisi, inmenin farklı dönemlerine göre değişiklik göstermektedir. Akut (<1 ay) ve subakut (1–3 ay) dönemlerde uygulanan TMS'nin, özellikle akut dönemde daha belirgin olmak üzere, kronik döneme kıyasla üst ekstremite motor fonksiyonlarının iyileşmesinde daha etkili olduğu gösterilmiştir (103). rTMS'nin alt ekstremitede etkisi ise motor korteksteki bacak temsil alanının hedeflenmesindeki doğruluk sorunları ve uygulanan hedef bölgelerdeki değişkenlik nedeniyle heterojenlik göstermektedir (125).

Parkinson hastalığında, özellikle motor ve prefrontal kortekslere uygulanan rTMS'nin; bradikinezi, yürüme bozuklukları, depresyon ve bilişsel işlev bozukluğu gibi semptomlar üzerinde sınırlı ancak anlamlı iyileşmeler sağladığı bildirilmektedir (126). Bununla birlikte, frekans, yoğunluk, hedef bölge ve seans sayısı açısından stimülasyon protokollerindeki heterojenlik, rTMS'nin optimal etkisinin anlaşılmasını güçleştirmektedir (126, 127).

Multipl sklerozda (MS), TMS çalışmalarının büyük ölçüde yorgunluk ve spastisite semptomlarına odaklandığı görülmektedir. MS'de genellikle M1, prefrontal korteks ve serebellum bölgelerine uygulanan rTMS'nin spastisiteyi azaltmada etkili olduğu gösterilmiş olup, spastisite yönetiminde kullanımı önerilmektedir (128). Bununla birlikte, MS'de rTMS'nin motor fonksiyon ve yorgunluk üzerindeki etkilerine ilişkin kanıtlar sınırlıdır (129).

Sonuç olarak, TMS'nin merkezi sinir sisteminde hedeflenen alanları aktive ederek nöroplastisite ve yeniden öğrenme için geçici bir etki oluşturduğu bildirilmektedir (130). Bu nedenle, klinik uygulamada TMS'nin tek başına kullanımı motor beceri kazanımını desteklemede nöroplastisiteyi sağlamak için yeterli olmayabilir (131). Fiziksel egzersiz ile rTMS'nin birlikte uygulanması, kortikal düzeyde nöroplastik değişiklikleri indükleyerek sinerjistik etki oluşturabilir ve tedavi etkinliğini artırabilir (132). Dolayısıyla, nörorehabilitasyonda rTMS'nin egzersiz temelli yaklaşımlarla kombine uygulanması önerilmektedir (133).

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NÖROFİZYOTERAPİDE GÜNCEL KONULAR

Nursel ÖZİRİ [1]

Nörofizyoterapide robotik rehabilitasyon, sanal gerçeklik, telerehabilitasyon, motor imgeleme, oyunlaştırma, bilişsel egzersizler ve yapay zekâ destekli uygulamalardaki gelişmeler rehabilitasyon pratiğini multidisipliner ve teknoloji odaklı bir yapıya dönüştürmüştür. Bu doğrultuda nörofizyoterapide güncel konuların incelenmesi, rehabilitasyon süreçlerinin etkinliğinin artırılması açısından önem taşımaktadır.

BİLİŞSEL EGZERSİZLER

Giriş

Bilişsel egzersizler; dikkat, bellek, yürütücü işlevler ve problem çözme gibi üst düzey bilişsel süreçleri hedefleyen, yapılandırılmış ve tekrarlı karakterdeki terapötik modalitelerdir. Bu müdahalelerin temel mekanizması, hasar görmüş nöral ağlarının yeniden organizasyonunu (reorganizasyon) teşvik ederek işlevsel performansı optimize etmektir.

Literatür, bilişsel egzersizlerin etkisinin yalnızca bilişsel kapasite ile sınırlı kalmadığını; motor öğrenme, statik/dinamik denge, yürüyüş parametreleri ve günlük yaşam aktiviteleri (GYA) üzerinde de anlamlı iyileşme sağladığını göstermektedir (1,2). İnme sonrası nörolojik rehabilitasyonda kognitif müdahaleler, fonksiyonel iyileşmenin temel belirleyicilerinden biridir. Randomize kontrollü çalışmalar, standart fizik tedavi programlarına eklenen bilişsel egzersizlerin;

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zekâ destekli izlem sistemleri ile telerehabilitasyonun nörolojik rehabilitasyondaki rolünün daha da güçlenmesi beklenmektedir (76-78).

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