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Summary

Every single day we challenge ourselves and our bodies with movements that require motor skills. We move and use both fine and gross movements to either grasp things or e.g. walking. Furthermore, there is often a correlation between motor skills and physical activity level. Our motor skills are important in many contexts and in order to be able to cope with everyday life and adapt to our surroundings and participate in various activities, we need to develop motor skills during our lives. Such skills do not arise by themselves, but require us to practice and use the skills and this leads to improvements in our movements, e.g. in that movements become more precise both in terms of the position of the joints and the force development of the muscles. However, how we practice and learn new movements also seems to be different depending on the age and thus also neurophysiological maturation processes.

The purpose of this PhD thesis is to investigate the relationships between motor skills, physical capacity and executive functions in preadolescent children and then to investigate whether motor practice with an emphasis on either position control or force control leads to different effects on precision and force development in preadolescent children and young adults.

This was done through the collection of data through tests of motor performance, cognitive (executive) function and physical capacity and in a cross-sectional study that included 270 preadolescent children aged 9-11 years (Study I), as well as by collecting behavioral data on motor performance, motor learning and neurophysiological data in Study II and III from 44 preadolescent children aged 9-11 years and 66 young adults aged 20-30 years respectively.

Study I investigated associations between motor, cognitive and physical performance in preadolescent children between 9-11 years of age. The results demonstrate significant associations between performance in several of the measured motor skill domains and that there are associations between fine motor skills and executive functions as well as between physical capacity measured as hand grip force and executive functions.

In *Study II*, the effects of dynamic and isometric motor practice on motor skill related behavioral and neurophysiological parameters in 9-11-year-old (preadolescents) children were investigated. The results show that preadolescent children become more precise in their position control after dynamic training, while isometric training does not lead to improvements in force control. Furthermore, the results show that there are significant but low levels of corticomuscular coherence during the hold-phase in both the dynamic and isometric version of the motor task. Following motor practice, there were however no changes in corticomuscular coherence in children at the age of 9-11y irrespective of the type of motor practice.

Study III also examined the effects of motor practice on motor skills related behavioral and neurophysiological parameters, but in this study the participants were young adults. The results show improvements in both position and force control after dynamic training, while isometric training only results in improvement of force control and does not have the same transfer effect for positional control. The results also show that the dynamic practice leads to increased corticospinal excitability compared to what is observed following isometric training.

Overall, the thesis contributes with new knowledge about motor skills and motor learning in pre-adolescent children and young adults. The results from Studies II and III contribute to a better understanding of age-related differences in motor learning, both in terms of the specific motor performance measures and in relation to underlying neurophysiological mechanisms.

Dansk Resume

Hver eneste dag udfordrer vi os selv og vores krop med bevægelser, som kræver motoriske færdigheder. Vi bevæger os og bruger både fine og grove bevægelser for at tage fat om ting eller f.eks. gå. Desuden er der ofte en sammenhæng mellem motoriske færdigheder og fysisk aktivitetsniveau. Vores motoriske færdigheder er vigtige i mange kontekster og for at kunne begå os i hverdagen og tilpasse os omgivelser og indgå i forskellige aktiviteter har vi brug for at udvikle motoriske færdigheder i løbet af vores liv. Sådanne færdigheder opstår ikke af sig selv, men kræver at vi øver os og træner og dette fører til forbedringer af vores bevægelser f.eks. ved at bevægelser bliver mere præcise både hvad angår leddenes position og musklernes kraftudvikling. Hvordan vi træner og lærer nye bevægelser, ser dog også ud til at være forskelligt afhængig af hvilken alder og dermed også neurofysiologiske modningsprocesser.

Nærværende Ph.d.-afhandling har til formål at undersøge hvilke sammenhænge der er mellem motoriske færdigheder, og fysisk kapacitet samt eksekutive funktioner hos tweens og derefter at undersøge om motorisk træning med fokus på enten positionskontrol eller kraftkontrol medfører forskelligartede effekter på præcision og kraftudvikling hos tweens og unge voksne.

Dette blev gjort gennem indsamling af data fra test af motoriske færdigheder, kognitive (eksekutive) funktioner, og fysisk kapacitet i et tværsnitsstudie der inkluderede 270 børn i alderen 9-11 år (studie I) samt ved indsamling af adfærdsdata på motoriske færdigheder, motorisk læring og neurofysiologiske data i Studie II og III fra hhv. 44 børn i alderen 9-11 år og 66 forsøg med unge voksne i alderen 20-30 år.

Studie I undersøgte associationer mellem motorisk, kognitiv og fysiske færdigheder hos børn i alderen 9-11 år. Resultaterne demonstrerer signifikante associationer mellem færdigheder i flere af de målte motoriske færdighedsdomæner og at der er associationer mellem finmotoriske færdigheder og eksekutive funktioner lige så vel som mellem fysisk kapacitet målt ved håndgrebsstyrke og eksekutive funktioner.

I **studie II** undersøgtes effekterne af dynamisk eller isometrisk motorisk træning på adfærds- og neurofysiologiske parametre hos 9-11-årige børn (tweens). Resultaterne viser, at tweens bliver mere præcise i deres positionskontrol efter dynamisk træning, mens isometrisk træning ikke medfører forbedringer af kraftkontrol. Desuden viser resultaterne at der er signifikante, men lave niveauer af cortico muskulær coherens under hold-fasen i både den dynamiske og isometriske version af den motoriske opgave. Efter træning var der dog, uanset typen af træning, ingen ændring i cortico muskulær coherens hos børn i alderen 9-11 år.

Studie III undersøgte effekterne af motorisk træning på motoriske færdigheder relaterede adfærds- og neurofysiologiske parametre, men i dette studie var deltagerne hos unge voksne. Resultaterne viser forbedringer i både positions- og kraftkontrol efter dynamisk træning, mens isometrisk træning ikke har samme transfer effekt til positionskontrol, men kun medfører forbedring af kraftkontrol. Resultaterne viser også, at den dynamiske træning medfører øget corticospinal excitabilitet sammenlignet med observationerne efter den isometriske træning.

Overordnet bidrager afhandlingen med nuanceret og ny viden omkring motorik og motoriske indlæringer hos børn og unge voksne. Resultaterne fra artikel II og III bidrager til en bedre forståelse af aldersrelaterede forskelle i forbindelse med motorisk indlæring både hvad angår de konkrete motoriske handlinger og i forhold til underliggende neurofysiologiske mekanismer.

Manuscripts included in the thesis

Manuscript I ***Executive functions are related to manual motor skills in preadolescent children***

Malene Norup, Jonas Rud Bjørndal, Meaghan Spedden, Linn Damsgaard, Jacob Wienecke, Laurits Munk Højberg, Anna Kinly Mogenssen, Richard Thomas & Jesper Lundbye-Jensen
Manuscript in progress.

Manuscript II ***Effects of position and force control motor practice on visuomotor accuracy and corticomuscular coherence in preadolescent children***

Malene Norup, August Lomholt Nielsen, Jonas Rud Bjørndal, Patrick Wiegel, Meaghan Spedden & Jesper Lundbye-Jensen
Manuscript submitted to Human Movement Science

Manuscript III ***Dynamic motor practice improves movement accuracy, force control and leads to increased corticospinal excitability compared to isometric motor practice***

Malene Norup, Jonas Rud Bjørndal, Patrick Wiegel, August Lomholt Nielsen & Jesper Lundbye-Jensen
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