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WATER TOREN

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Poster session

Abstract book

Summary

I. EXERCISE IS MEDICINE

Posters 1-9

Poster 1

DOES BED REST REDUCE BIOLOGICAL AGE IN HUMANS?

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Background: Epigenetic "clocks" are used to quantify human biological age using trained algorithms based on DNA methylation patterns. The use of biological age is therefore thought to be a better indicator of a person's health than chronological age. Recent evidence suggests that hypermetabolism accelerates biological ageing, but does the reverse also hold true? The epigenetic clock 'PhenoAge' [1] is based on circulating biomarkers related to the hallmarks of ageing.
Purpose: Here we utilized PhenoAge to test whether bed rest-associated hypometabolism reduces biological age in humans.
Methods: We measured the nine biomarkers required for the Horvath-Levine PhenoAge calculation (albumin, creatinine, glucose, C-reactive protein, lymphocytes, mean corpuscular volume, red blood cell distribution, alkaline phosphatase and white blood cell count), and determined biological age in 24 healthy individuals (age 33±9 years, 8 females) before and after 60 days of bed rest at the German Aerospace Center in collaboration with ESA and NASA, as part of the AGBRESA study.
Results: PhenoAge-assessed biological age highly correlated with chronological age (R^2=0.82). Biological age was not affected by bed rest (from 30.91 to 30.87 years), despite a two months increase in chronological age. Lower creatinine and mean corpuscular volume decreased biological age, while glucose, alakaline phosphatase and white blood cell count increased biological age.
Discussion: PhenoAge biomarkers have varying impact on a person's biological age, with some accelerating ageing and others showing a rejuvenation effect. It remains questionable whether the use of blood biomarkers as surrogate measures for the hallmarks of ageing are specific enough to detect the real underlying molecular mechanisms associated with ageing.

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Poster 2

ALTERED SKELETAL MUSCLE MITOCHONDRIAL MORPHOLOGY IN LATE MIDDLE-AGED HUMANS, DESPITE MAINTAINED MITOCHONDRIAL FUNCTION AND CONTENT

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Introduction: Ageing is typified by a decline in maximal oxygen uptake ($\dot{V}O_{2max}$), which can limit physical function and daily life activities. This decline in $\dot{V}O_{2max}$ is related to a lower skeletal muscle mitochondrial function and loss of muscle mass. However, data in humans are inconsistent, with many studies showing no difference in mitochondrial function between young and old or middle-aged groups.

Purpose: We aimed to determine maximal oxygen uptake ($\dot{V}O_{2max}$), mitochondrial respiration, density, and ultrastructure in late middle-aged and younger adults, and assess the interrelationships between mitochondrial measures, age, and $\dot{V}O_{2max}$.

Methods: 12 healthy young (27±5 years, 8 males) and 10 late middle-aged adults (55±6 years, 5 males) performed a $\dot{V}O_{2max}$ test on a cycle ergometer, and a muscle biopsy was obtained from the vastus lateralis for determination of mitochondrial respiration (respirometry), density and morphology (transmission electron microscopy), and succinate dehydrogenase (SDH) activity (histochemistry).

Results: $\dot{V}O_{2max}$ was lower in the late middle-aged compared to the younger group (34±5 vs. 45±7 $mL.kg^{-1}.min^{-1}$, $P<0.001$). Maximal oxidative phosphorylation capacity (old=99±27 vs. young = 99±17 pmol $O_2.s^{-1}.mg^{-1}$, $P=0.95$) and mitochondrial area density (old=6.2±1.5 vs. young = 6.0±0.5%, $P=0.86$) did not differ between groups, however, SDH activity was lower in old versus young subjects (old=0.97±0.18 vs. young=1.18±0.20 $*10^{-5}$ $\Delta A_{660}.\mu M^{-1}.s^{-1}$, $P=0.02$). Late middle-aged participants displayed smaller (old=66±5 vs. young=95±17 nm^2, P=0.001), but more numerous (old=0.71±0.13 vs. young=0.94±0.22 mitochondria.μm^{-2}, P=0.03) mitochondria when compared to younger participants. The area of individual mitochondria correlated negatively (r=-0.72, $P=0.004$), and the number of mitochondria per unit area of muscle correlated positively with age (r=0.63, $P=0.015$), respectively. Conversely, the area of individual mitochondria correlated positively (r=0.67, $P=0.006$) and the mitochondrial fragmentation index correlated negatively (r=-0.79, $P=0.0008$) with $\dot{V}O_{2max}$, respectively.

Conclusion: These data demonstrate that late middle-aged individuals had smaller, more numerous mitochondria for the same mitochondrial density and maximal respiration. The extent to which these mitochondrial structural alterations predispose skeletal muscle to ageing remains to be determined. Mitochondrial respiration did not differ between groups, but mitochondrial morphological measures were strongly correlated with $\dot{V}O_{2max}$ across groups, suggesting that mitochondrial morphological changes may be related to the age-related decline in $\dot{V}O_{2max}$.

Poster 3

DISCOVERY OF HEALTH ENHANCING PHYSICAL ACTIVITY PATTERNS USING ARTIFICIAL INTELLIGENCE

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Introduction Physical activity (PA) and sedentary behavior are linked to chronic non-communicable diseases, showing associations with cardiovascular risk. In previous studies, PA patterns were mainly classified according to the total activity time and activity intensity. We hypothesize that there is not such a thing as one healthy PA pattern. The challenge is to recognize characteristics of these healthy patterns at an individual level, and in a way that enables widespread integration of this in health promotion.
Purpose To identify the characteristics of healthy PA patterns and expose their beneficial contributions to health, we aim to use data driven techniques for pattern discovery to analyze the objectively measured PA data from the Maastricht Study, a cohort study involving 10,000 participants. Decision-making will be a combination of data-driven and hypothesis-driven research.
Method To filter the noise inside the core activity bouts, the event sequences derived from the activPAL sensors are dynamically merged according to the relative proportion of the core event duration to the adjacent events. Patterns such as 20 minutes' sedentary behavior interrupted by a 2-minute break were explored in controlled studies. We generalize these behavioral patterns by expanding the temporal boundaries and allowing alternative events to be involved. Additionally, clustering algorithms help to discover common and frequent patterns automatically in PA sequences. Given the sequential nature of physical activities and the multi-dimensional output of activity monitors, techniques designed for time series data are used to identify these characteristics. Finally, the relation of these characteristics with cardiometabolic health will be studied.
Results This study has currently completed the data preparation. The anticipated outcomes will result in a number of repeated and shared activity patterns that can be used to characterize the overall PA pattern of individuals as measured by activity trackers, and the methodology and technology to uncover them from activity tracker data.
Conclusions In this study, data driven techniques will enable us to look beyond crude estimates of PA and sedentary time to explore lifestyle at the individual level. The identified characteristics of a healthy PA pattern will also provide guidance for detailed studies by others in the future.

Poster 4

MUSCLE MORPHOLOGICAL ADAPTATIONS OF THE M. GASTROCNEMIUS MEDIALIS TO FUNCTIONAL POWER TRAINING IN CHILDREN WITH CEREBRAL PALSY: PROTOCOL OF A DOUBLE-BASELINE TRIAL

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Introduction
Children with cerebral palsy (CP) can experience muscle weakness and muscle shortening. This affects their gait pattern and their ability to run, which hinders participation in daily life activities.
A 12-week clinical functional training program with high-velocity power exercises specifically focused on the plantar flexor muscles has shown to improve walking and running ability in children with CP [1]. However, strength training has also been shown to increase muscle tightness [2]. This adverse effect of strength training could aggravate muscle shortening in CP. In contrast, van Vulpen et al. [1] found a slight increase in range of motion of the ankle following the functional training program. We hypothesize that this increase was achieved by muscle fiber hypertrophy which, due to the pennate structure of the plantar flexor muscles, will result in an increase of muscle length. However, the effect of the functional training program on the plantar flexor muscle morphology, i.e. muscle and fiber length is yet unknown.

Purpose
Our aim is to investigate the effects of a 12-week functional power training program on muscle morphology of the m. gastrocnemius medialis in children with spastic CP.

Method
Twenty-three children with spastic CP participating in the functional power program will be included in this double-baseline study. Morphological variables of the m. gastrocnemius medialis, i.e. muscle-tendon unit length, muscle belly length, tendon length and fascicle length will be obtained twelve weeks before the training (T0), just before the training (T1), and after completion of the training (T2) using 3D ultrasound [3]. Changes in the morphological variables during the period of usual care (T1-T0) will be compared to changes during the training period (T2-T1) using paired t-tests. So far, we have collected data of ten children.

Conclusion
This study gives insight into the working mechanisms of the functional power program and will elucidate whether it is suitable for both strengthening and lengthening of the calf muscle. This new information can be used to further improve the program.

References
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Poster 5

EFFECTIVENESS AND IMPLEMENTATION OF A COMBINED LIFESTYLE INTERVENTION FOR OUTPATIENTS WITH SEVERE MENTAL ILLNESS (GOAL!): A QUASI-EXPERIMENTAL STUDY PROTOCOL

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Introduction: In addition to their impaired mental health, people with severe mental illness (SMI) have a higher risk of developing cardiometabolic disorders such as cardiovascular disease and diabetes. It contributes to an up to 15-year shorter life expectancy compared to the general population. A lifestyle with little exercise, unhealthy eating and sleeping patterns, and substance use such as smoking plays a substantial role in both their disadvantaged mental and physical health. While multidisciplinary intervention with attention to multiple lifestyle factors can improve overall health and quality of life, there is currently no appropriate structural support for people with SMI in outpatient care in the Netherlands. The Combined Lifestyle Intervention for Outpatients with severe mental illness (GOAL!) is developed to address this gap.
Purpose: This study evaluates the long-term health outcomes, implementation, and cost-effectiveness of GOAL!.
Method: In a quasi-experimental study with a mixed-method matched design, participants (N=50) are compared to usual care (N=50), recruited in another region to prevent contamination. Participants receive two years of group and individual support from lifestyle coaches and qualified professionals tot sustainably adopt a healthier lifestyle. The first year starts with a 3-month intensive course on exercise and nutrition, followed by 9 months of aftercare covering various lifestyle topics. There is close collaboration with local organizations to facilitate a transfer to the social domain. The second year focuses on maintaining the established activities in the neighborhood. Using multiple regression analyses we evaluate effects on physical activity as primary outcome. Secondary outcomes include other lifestyle factors, physical and mental health outcomes, care and social costs, and implementation factors.
Results: The first results are expected in 2025.
Conclusion: By evaluating the long-term effects of GOAL!, we obtain insight in the (cost)effectiveness and implementation of a combined lifestyle intervention for people with SMI in outpatient care.

Poster 6

1. THE COST OF WALKING AND GAIT PARAMETERS IN PERSONS WITH RHEUMATOID ARTHRITIS DO NOT DIFFER FROM CONTROL SUBJECTS DESPITE HIGHER LEVEL OF FATIGUE AND SLOWER SELF-SELECTED WALKING SPEEDS

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Introduction: Despite numerous studies assessing fatigue in persons with Rheumatoid Arthritis (RA) and while impairments in physical functions are known to affect gait, a detailed analysis including the Cw and spatiotemporal gait parameters is lacking. Providing a comprehensive overview of the Cw and gait parameters at self-selected and different imposed fixed speeds, will contribute to understanding whether gait alterations in pwRA could play a role in the elevated levels of fatigue

Purpose: This study aimed to determine whether the Cost of walking (Cw) and gait parameters in Persons with Rheumatoid Arthritis (pwRA) coincide with fatigue by comparing the self-selected walking speed and the speed with the lowest Cw between pwRA and controls, as well as by analysing differences in Cw and gait parameters at fixed speeds.

Method: 28 pwRA and 22 matched controls (age:53±13, 52±10 years; weight:74±12, 72±12 kilograms, respectively) walked at self-selected and fixed speeds (0.75; 1.00; 1.25; 1.50; 1.75m/s) on an instrumented treadmill while energy-expenditure was measured via indirect calorimetry. Self-reported fatigue was compared between-groups. The speed with the lowest Cw was derived from a 2nd order polynomial equation that was fitted to the individual speed-Cw data. The self-selected- and speed with the lowest Cw were compared between and within-groups with a t-test. Linear mixed models were used to compare differences in Cw and spatiotemporal parameters (step length; step width; cadence) at fixed speeds between groups.

Results: PwRA reported higher fatigue levels and walked at slower self-selected speeds than controls (1.26 vs. 1.40m/s). Self-selected speed in PwRA differed from the speed with the lowest Cw (1.37m/s) but not from the speed with lowest Cw of controls (1.38m/s). Only step-length was shorter in pwRA.

Conclusions: The self-selected walking speed in pwRA is slower and energetically more costly, compared to controls. Despite the high levels of fatigue in pwRA, this does not coincide with altered gait at fixed speeds compared to controls. Therefore, gait training in pwRA should focus on increasing the self-selected walking speed to energetically benefit from walking faster.

Poster 7

EFFECT OF A 14 WEEK FRAME RUNNING TRAINING PROGRAM OM CARDIORESPIRATORY FITNESS AND PSYCHOSOCIAL FUNCTIONING

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Introduction: Frame Running is a new para-athletic sport for people with mobility impairments. The sport could improve cardiorespiratory fitness because high heart rates can be achieved during training.

Purpose: The aim of this prospective pre-post intervention study is to investigate changes in cardiorespiratory fitness and psychosocial functioning after a 14-week training program (once a week) in children and adolescents who start Frame Running.

Method: Starting Frame Running athletes (age 6 to 18 years) were recruited via their trainer. Cardiorespiratory fitness was measured with the 6 Minute Frame Running Test (6MFRT) and the Shuttle Frame Running Test (SFRT) at baseline and at the end of a training program. Psychosocial functioning was measured with the Psychosocial Impact of Assistive Devices Scale (PIADS) at the end of a training program. Non-parametric tests (Wilcoxon signed rank test) were used for statistical analyses.

Results: Eight participants (5 boys), median age 10.5 years (range 6-17), diagnosed with CP (n=4), syndromes (n=3) and SMA (n=1), functioning as GMFCS level II (n=7) and III (n=1) were included so far.
The median distance on the 6MFRT improved from 791 m (range 420-1080 m) to 818 m (range 640-1076) *(n.s.)* and the median shuttle score on the SFRT improved from 10.75 (6.5-20.0) to 11.75 (7-22) *(n.s.)*.
The median score after training for the domain competence of the PIADS was 0.92, for the domain adaptability 1.0 and for the domain self-image 0.75, which all differed significantly from score 0/'no change' (p=0.018). The highest median scores were for the items independence and well-being (both 2.0) and happiness, self-esteem, self-confidence and participation (all 1.5).

Conclusion: Psychosocial functioning in starting Frame Running athletes increased after a training program, with high scores on independence and well-being. Cardiorespiratory fitness also increased, although not significantly. Possibly the training frequency was not high enough and/or the training period was not long enough for significant change in cardiorespiratory fitness. Moreover, the number of participants is still small. New participants are still being enrolled.

Poster 8

ACUTE EFFECTS OF A STAB LESION ON MECHANICAL PROPERTIES OF THE L4/L5 INTERVERTEBRAL DISC IN THE RAT

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Introduction. Low back pain (LBP) is one of the most common musculoskeletal problems. LBP may coincide with altered motor behaviour due to mechanical changes in mechanical properties of the spine resulting from injury or degeneration (i.e. decreased spine stability), or due to effects of nociception on neuromuscular control. The relative importance of these mechanisms, and their possible interaction, are unknown[1]. Our overall objective is to assess the effects of nociception and spine instability, and their interaction on trunk muscles activity and body movement in a rat model. A first step is to quantify the acute effects of disc lesion on spine mechanical properties.

Purpose. To assess the acute effects of IVD lesion on the mechanical properties of the L4/L5 IVD.

Method. 27 L4/L5 spinal segments were collected from Wistar rats (male/female=14/13, body weight=345.6±85.8 gram, age=12.7±0.7 weeks) within 2 hours after sacrifice, stored at -20℃. Following thawing, bending tests were performed to assess the intersegmental angle-moment characteristics. Specimens were loaded in three target directions (right bending/left bending/flexion) before and after IVD lesion.

Results. SPM analysis indicated that in right bending, no significant changes in angle-moment relationships were found (Fig. 1A), but in left bending and flexion, significantly lower angle-moment curves were found after lesion (Fig.1B-C). Peak stiffness, peak moment, and hysteresis were significantly decreased (6%-11%, effect size: 0.13-0.26) after lesion in all directions.

Conclusions. Stab lesion of the L4/L5 IVD in the rat caused small to moderate acute changes in IVD mechanical properties. We have previously reported the timing of the structural changes of the IVD to this lesion[2], but the relationship between IVD structure and mechanical function has not yet been established. Our next step will be to evaluate the long-term effects of IVD lesion on spine mechanics and neural control of trunk muscles.

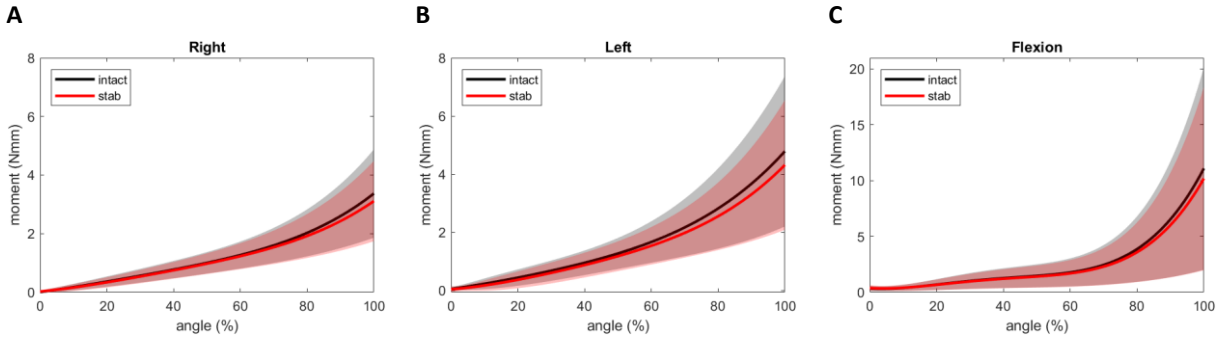

Figure 1. Angle-moment curves in **(A)** Right bending **(B)** Left bending **(C)** Flexion for Intact (black) and stabbed disc (red). Moments are plotted as a function of normalized bending angle, and presented as mean with 95% confidence interval. (sample size: Right=10, Left=10, Flexion=7)

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Poster 9

STREPTOMYCIN INHIBITS CELL DIFFERENTIATION BY IMPACTING ENERGY METABOLISM AND PROTEIN SYNTHESIS IN SKELETAL MUSCLE

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Introduction: Antibiotics are widely used to treat or prevent bacterial infections. Antibiotics will kill bacteria or inhibit their growth such that the immune system can fight off the remaining infection. A downside of antibiotics use, particularly of streptomycin, is that it also may affect the function of many other body cells such as skin cells, hepatocytes and skeletal muscle cells. Decline in function of these latter may impair the athletic performance and recovery after injury. As yet little is known about the effects of streptomycin on muscle stem cell proliferation, myofiber protein synthesis and hypertrophy as well as mitochondrial function.
Purpose: We studied the effect of streptomycin on C2C12 myoblasts and myofiber function.

Methods: C2C12 cells were cultured in a medium with or without streptomycin. Proliferation rate was assessed by the EdU assay, and myofiber diameter, differentiation and fusion index were measured after 6 days exposure of differentiated myotubes to streptomycin. The gene and protein expression of key markers of contractile and mitochondrial function, protein synthesis and degradation were conducted by qPCR, western blotting. The SUnSET assay was used to determine overall protein synthesis rates. Mitochondrial respiration was performed to measure the mitochondrial respiration and metabolism. The control condition consisted of carbenicillin and ampicillin treatment to avoid contamination of the medium with bacteria.

Results: Streptomycin did not impair the proliferation rate. After 6 days of differentiation with streptomycin, myotubes were thinner and had a lower differentiation and fusion index, compared to groups without streptomycin. Streptomycin reduced the global protein synthesis rate in C2C12 myotubes, while other markers of protein synthesis or degradation were not affected. Streptomycin did not impair mitochondrial respiration in C2C12 myotubes, but protein content of subunits of mitochondrial complex I was lower, and metabolism-related gene expression of SDHB was lower. Contractility-related genes Myh3 and α-actin also had lower expression after streptomycin exposure.

Conclusions: Streptomycin does not alter myoblast proliferation, but can reduce protein synthesis rates in cultured myotubes causing a blunted growth response. Minor changes were observed in mitochondrial metabolism. The use of streptomycin should be carefully considered with regard to the side effects on skeletal muscle. Other antibiotics such as carbenicillin and ampicillin are recommended, if muscle function is to be preserved, provided that the bacteria are responsive to these.

II. Healthy Generation

Posters 10-14

Poster 10

HOW INTRINSICALLY MOTIVATING ARE SWIMMING INSTRUCTORS / LESSONS IN THE NETHERLANDS? AN OBSERVATIONAL STUDY THROUGH THE LENS OF SELF-DETERMINATION THEORY

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Introduction: It is desirable that (more) children continue swimming after having completed their swimming lessons to preserve their swimming skills and water safety, and as part of an active, healthy lifestyle. This may be encouraged by stirring children's intrinsic motivation for swimming during swimming lessons. However, it is currently unknown how intrinsically motivating swimming lessons are in Western countries.
Purpose: This study examined to what extent swimming instructors in the Netherlands cater to the basic needs of autonomy, competence, and relatedness, which, according to Self-Determination Theory (SDT), promote intrinsic motivation. Additionally, it examined whether an SDT-based teaching program prompts instructors to better meet these needs, and to what extent the teaching program, the education and experience of the instructor, and group size predict the employment of SDT in swimming lessons.
Method: A total of 128 swimming lessons given by equally many instructors were observed in the Netherlands and rated on a modified version of the SDT teaching style scale to assess autonomy, competence, and relatedness support. The swimming lessons referred to four teaching programs, one of which was explicitly based on SDT.
Results: Instructors exhibited autonomy-thwarting, and weakly competence-supportive, and relatedness-supportive behaviors. The SDT-based teaching program scored higher on the provision of autonomy, competence, and relatedness in lessons. This finding was significant for autonomy. Teaching program was the only significant predictor of SDT employment by instructors.
Conclusions: Further improvement is desirable in catering to the basic needs, particularly autonomy, which can be achieved by deliberately implementing the principles of SDT into teaching programs for swimming.

Poster 11

Title: **PROMOTING ACTIVE SITTING AT ELEMENTARY SCHOOLS USING AN AFFORDANCE-BASED DESIGN APPROACH**

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Abstracts:
Children spend a significant portion of sitting time in school classrooms. Prolonged sitting at a young age is an important risk factor for chronic diseases (e.g., overweight, cardiovascular diseases). Increasing active behaviors is therefore an important target for health promotion. This research aims to make sitting itself more active.

The concept of affordances, which is originally from ecological psychology, refers to people perceiving the environment in terms of what it affords for action. Studio Lentala is inspired by this concept to create the stools without a backrest. LENTALA stools are designed to invite multiple sitting postures and elicit more changes between postures (Fig. 1).

The research aims are twofold. The primary aim is to design, implement and evaluate a classroom-based intervention to permanently increase children active sitting using Lentala stools. The secondary aim is to develop and validate quantitative methods to measure sitting activity in school settings. To achieve these aims, I have divided the project into four studies.

Study 1: Proof of concept
To evaluate whether Lentala stools can induce more posture changes compared to sitting on traditional chairs. Lentala stools were used in primary school classes for ten days. We measured active sitting by the number of different postures, the number of changes between postures and the dominant posture. Preliminary analyses suggest the LENTALA stools promote active sitting (Fig. 2).

Study 2: Cross-validation of the level of activity
To verify that the expected differences in a variety of sitting postures and alternation between postures for Lentala stools and traditional chairs reflect different degrees of level of activity in sitting by using electromyography and oxygen-uptake in the laboratory.

Study 3 Literature review on classrooms-based interventions
A review to investigate methodology, design and outcomes of existing classrooms-based interventions to change children's sitting behaviors. The purpose is to get insight in the effectivity of current designs and programs for creating long-term differences in children's sitting behaviors in preparation to study 4.

Study 4 Long-term classroom intervention
To undertake a randomized controlled trial to compare the long-term benefits of Lentala stools on active sitting and academic performance relative to the traditional chairs.

Figure 1. Lentala stools

Figure 2. 10 sitting postures induced by Lentala stools

Poster 12

A prospective analysis of physical activity and mental health in children: the GECKO Drenthe Cohort

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(Words: 339, excluding title, names, and affiliation)

Introduction Mental health problems in young people have become a global health burden. The positive effects of physical activity on mental health in adults are well known but still not clear in children.

Purpose The aim of this study was to investigate to what extent physical activity in early childhood would affect mental health in middle childhood.

Method From the Dutch GECKO Drenthe birth cohort, 850 children (51.5% boys) were enrolled in this analysis. Physical activity (PA) and sedentary time (ST) was objectively measured at age 5-6 using ActiGraph GT3X. Mental health was assessed using the Strengths and Difficulties Questionnaire (SDQ) at age 5-6 and age 10-11. Multiple linear regression models were used to estimate the associations between PA, ST and SDQ subscales, stratified by gender, and adjusting for age, BMI, maternal education level, family size, accelerometer wearing time and season, and additionally adjusting for SDQ scores at age 5-6 to take tracking of mental health over time into account.

Results Greater PA volume at age 5-6 was associated with lower peer problems scores at age 10-11 in boys and girls. An increase in MVPA was associated with lower peer problems scores in boys (b=-0.445, -0.713 to -0.176) and girls (b=-0.354, -0.601 to -0.107), however, increased ST was linked to higher peer problems scores in boys (b=1.18, 0.455 to 1.906) and girls (b=0.870, 0.191 to 1.550). For hyperactivity, higher levels of PA volume and MVPA were associated with higher hyperactivity scores in boys. Increased ST was related to lower hyperactivity scores in boys. Further adjustment for SDQ scores at age 5-6 attenuated all associations between PA and hyperactivity in boys but hardly changed the relationships with peer problems. No significant associations between PA and other SDQ subscales or total difficulties scores were observed, neither in boys nor in girls.

Conclusions Children who are more physically active and have less sedentary time at age 5-6 have fewer peer problems at age 10-11, and for boys, greater activity levels at age 5-6 could be an indicator of hyperactivity at age 10-11.

Poster 13

Mechanisms of Acute Effects of Physical Activity on Cognitive Function in Healthy Young Individuals: Preliminary Results of a Systematic Review of Randomized Controlled Trials

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Purpose: The aim of this systematic review is to summarize the acute effects of physical activity (PA) on cognitive function in healthy young individuals, and further address possible underlying mechanisms.

Methods: Three databases (PubMed, Web of Science, and Medline) were searched until February 2023. Inclusion criteria were: randomized controlled trials; healthy (young) individuals aged 18-35 years old; acute effects of PA; with primary outcome and at least one of the secondary outcomes. The primary outcome was cognitive function, and the secondary outcomes were cerebral blood flow (CBF), circulating parameters (BDNF, lactate, IGF-1, glucose, 5-HT) and salivary parameters (cortisol).

Results: The search resulted in 35 articles. So far, the 13 articles focusing on circulating parameters have been abstracted, of which 8 focused on BDNF, 4 on lactate, 3 on IGF-1, 1 glucose and 5-HT, and 2 on salivary cortisol. Interventions included high-intensity interval exercise (HIIT), high, moderate, or low-intensity exercise, aerobic exercise (AE), resistance exercise (RE), and the comparison of PA types and intensity. Cognitive domains included executive function, working memory, attention, inhibitory control, cognitive flexibility.

About exercise intensity, all HIIT studies revealed its positive effect on cognition with increased circulating BDNF, and lactate. High-intensity but not low-intensity PA led to better memory compared to controls.

About exercise types, both AE and RE benefited cognition, but salivary cortisol did not change following acute PA. Acute AE enhanced 5-HT levels, which was associated with improved response inhibition. However, breaking up sitting with RE did not benefit cognition, but did lead to increased glucose levels compared with prolonged sitting.

Conclusion: This study revealed acute beneficial effects of PA on cognitive performance in young individuals. Exercise intensity and types could be the key factors in cognition-improving following PA. The changes in circulating biomarkers, including BDNF, IGF-1, lactate, glucose, 5-HT, and salivary cortisol may play a role to explain the underlying mechanisms. The remaining studies need to be explored and summarized to further understand the mechanisms of acute effects of PA on cognitive function.

Poster 14

REDEFINING PERCEPTUAL SKILL IN PHYSICAL EDUCATION TEACHERS: AN ECOLOGICAL APPROACH

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Introduction
Quality physical education (PE) is considered critical for increasing physical activity participation, and hence health and wellbeing. Quality PE depends on quality PE teaching. PE teachers use observation to assess and support student learning. Student learning is therefore contingent on the perceptual skill of PE teachers.

Purpose
To develop an ecologically valid definition of perceptual skill in PE teachers.

Literature review
Perceptual skill in PE teachers is almost exclusively defined as accurate perception of movement errors relative to a criterion movement pattern. It is assumed that detecting errors enables PE teachers to correct errors, which enables students to develop motor skills. Nevertheless, research consistently shows that PE teachers do not accurately perceive movement errors, and that experienced PE teachers are just as inaccurate as preservice PE teachers. Training interventions, however, improve movement error perception in preservice PE teachers. It is thus concluded that PE teachers lack perceptual skill and require deliberate practice for its development.

Discussion
Inaccuracy in movement error perception does not necessarily mean that PE teachers lack perceptual skill; it may simply be inessential to quality PE teaching. There are three reasons for this view: 1) movement variability is not necessarily movement error, 2) PE aims to also develop social and emotional skills, and 3) perception is primarily of possibilities for action, or affordances. Considering the diversity of goals in PE, abilities required to achieve these goals, and situations that arise during PE lessons, PE teachers have a rich landscape of teaching affordances to perceive. Perceptual skill in PE teachers can be defined as the degree to which a PE teacher can perceive this landscape. Perceiving a broader range of teaching affordances enables PE teachers to adapt their teaching relative to the context and their goals.

Conclusions
While it is typically concluded that PE teachers lack perceptual skill, it is plausible that the traditional definition of perceptual skill in PE teachers lacks ecological validity. Quality PE teaching depends on PE teachers adapting PE teaching to the particular context. To do this, PE teachers need to perceive the rich landscape of teaching affordances that PE lessons offer.

III. Moving smarter and better

Posters 15-26

Poster 15

SELF-CONTROLLED VIDEO FEEDBACK FACILITATES THE LEARNING OF TACTICAL SKILLS IN TENNIS

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Introduction: Providing feedback effectively is highly relevant for supporting the acquisition of sport skills. One crucial aspect to increase performance is the feedback schedule, that it is the timing and frequency of feedback provision. In recent years, researchers have demonstrated that giving learners control of when to receive feedback increases learning compared to externally controlled conditions, where a coach (or experimenter) decides and provides feedback. Despite an increasing amount of evidence showing benefits of self-controlled feedback when learning *technical* motor skills, the effect of self-controlled feedback on acquiring *tactical* skills needs more investigation. **Purpose:** This study aimed to examine the effect of self-controlled video feedback on the learning of tactical motor skills in tennis. **Method:** 23 intermediately skilled tennis players were quasi-randomly assigned to either a self-controlled group that was provided feedback on request or a yoked group that received an identical, externally controlled feedback schedule. In three training sessions participants practiced serve and volley play. Video feedback with attentional cueing and transitional statements that focused solely on individual tactical gameplay was provided by a licensed tennis coach. Individual tactical performance was measured with a custom designed Tactical Tennis Test (TTT) in a pretest, posttest and in a one-week retention test. **Results:** ANCOVA with pretest score as covariate revealed that the self-controlled group showed a significantly larger improvement in tactical performance than the yoked group in the posttest and in the one-week retention test. **Conclusion:** The advantage of self-controlled video feedback extends to the learning of a complex tactical task in tennis.

Poster 16

HOW LONG DOES IT TAKE TO PHYSICALLY AND PSYCHOLOGICALLY RECOVER AFTER AN INJURY IN SOCCER?

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Introduction: When soccer players sustain an injury, they generally have to recover, both physically and psychologically. The process of recovery after an adversity such as an injury can be defined as resilience.[1] Despite its importance, individual resilience after a time-loss injury has never been quantified before.

Purpose: This study aimed to quantify resilience in terms of both physical and psychological variables after time-loss injury in individual soccer players.

Method: We followed 58 elite youth soccer players who sustained time-loss injuries during the 2020/2021 and 2021/2022 seasons. For each individual, we monitored the training load, perceived recovery, motivation, self-efficacy, mood, and enjoyment for every training and match day. We quantified resilience using these variables following injury by fitting multiple growth models. Next, we identified the best one using the Bayesian information criterion.[2] Then we used the predicted values from the selected model to identify the time point at which the physical and psychological variables should return to baseline levels.

Results: 25 of the 58 soccer players experienced a significant drop in physical or psychological variables following an injury. For three soccer players, the psychological variables self-efficacy and mood did not return to baseline levels even though these players resumed training. Accordingly, the average duration between the day of the injury and the predicted day of return to baseline was lower for the physical variables (training load = 20.5 days and recovery = 73.5 days) than for the psychological variables (motivation = 358 days, self-efficacy = 114.8 days, mood = 104.4, and enjoyment = 70.25 days). However, these trajectories were highly individual-specific.

Conclusions: Injuries often lead to a significant decrease in the physical and psychological variables of soccer players. Although the recovery trajectory after an injury is highly individual-specific, the recovery of psychological variables often requires more time than the recovery of physical variables. Practitioners can use these findings during the multidisciplinary and personalized rehabilitation of injured players.

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Poster 17

SPRINT AND ENDURANCE PERFORMANCE IN YOUNG ELITE SOCCER PLAYERS AT DIFFERENT PLAYING POSITIONS

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Introduction Soccer players have to perform many consecutive sprints at high speed, requiring a combination of both sprint and endurance abilities. Previous literature in other sports has shown an inverse relationship between sprint and endurance performance, suggesting that optimizing these two physical traits simultaneously is challenging.

Purpose This study investigates the relationship between sprint and endurance performance in soccer players, with respect to individual playing positions and match-specific outcomes.

Methods Twenty-four young elite soccer players at a professional football club (U18 & U21, age = 18.0 ± 1.2, height = 180.0 ± 6.7, weight = 72.9 ± 8.7; mean ± standard deviation) performed a maximal incremental treadmill test with gas exchange analysis to measure their $\dot{V}O2_{max}$, which was normalized to lean body mass$^{2/3}$ to eliminate the influence of body size. In addition, sprinting speed was measured over 20 meters using local position measurement. Linear regression analysis was used to evaluate the association between the sprint performance and normalized $\dot{V}O2_{max}$. Moreover, match-specific performance data was obtained. Differences in sprint and endurance test and match performance outcomes were compared between player positions (forwards (F), attacking midfielders (AM), defending midfielders (DM), backs (B) and central defenders (CD) using one-way ANOVA.

Results No significant association between the average sprint speed and the normalized $\dot{V}O2_{max}$ was found in this player group (R^2 = 0.09; p = 0.11). There were also no significant differences in sprint speed (p>0.32) or normalized $\dot{V}O2_{max}$ (p>0.45) between positions. However, substantial differences were shown within groups. Also, there were match-specific differences in total distance (DM = AM = F > B > CD, p<0.05) and total sprint distance (B = F > DM = CD, p<0.05; B > AM > CD, p<0.05).

Conclusions Although there were differences in match performance outcomes, these were not reflected in the maximal sprint and endurance capacity of the present group of young elite players and no significant relationship between these two physical traits could be found. Maximal sprint and endurance performance values did vary substantially between groups, which suggests that some players may benefit from individualized training. Implications for optimization of training are discussed.

Poster 18

$\dot{V}O_{2max}$ IN ELITE SWIMMERS: COMPARING THE VALIDITY, TEST-RETEST RELIABILITY AND PRACTICAL APPLICABILITY BETWEEN CYCLING, ARM-CRANKING, ERGOMETER SWIMMING AND TETHERED SWIMMING

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Introduction Endurance capacity is a critical success factor in most swimming events, particularly for race distances longer than 100m. In swimming, a substantial proportion of the energy in skeletal muscles is generated aerobically. While the maximal oxygen consumption ($\dot{V}O_{2max}$) is considered the gold standard for the assessment of endurance capacity, conducting sport-specific measurements of $\dot{V}O_{2max}$ in the water can be challenging, expensive and time-consuming. Additionally, it remains unknown to what extent non-sport-specific tests can explain endurance performance in swimming.

Purpose This study aimed to determine the method with the highest validity, test-retest reliability, and practical applicability for measuring $\dot{V}O2_{max}$ in elite swimmers.

Methods Twenty elite swimmers (age = 18.7 ± 1.7, height = 182.6 ± 8.3, weight = 74.2 ± 8.0; mean ± standard deviation) performed four maximal incremental exercise tests in randomized order: cycling, arm-cranking, ergometer swimming and tethered swimming. Gas analysis was conducted to measure $\dot{V}O_{2max}$. Endurance performance was evaluated during a 1500m time trial. Linear regression between the four $\dot{V}O_{2max}$ measurements and the 1500m time trial was used to determine the validity of the tests. A subset of 11 swimmers repeated the tethered swimming test twice to determine its test-retest reliability, which was quantified using the intraclass correlation coefficient (ICC). Practical applicability was assessed based on costs, accessibility, number of testers required, susceptibility to error and sport-specificity for each test.

Results Tethered swimming, ergometer swimming and cycling all had similar explained variance of the 1500m swimming performance (R^2 = 0.64, 0.64, 0.65, respectively). However, ergometer swimming showed significantly lower $\dot{V}O_{2max}$ values (40.54±6.55 ml/kg/min) than tethered swimming (54.40±6.21 ml/kg/min) and cycling (54.39±5.63 ml/kg/min). Arm-cranking showed both a significantly lower $\dot{V}O_{2max}$ (43.14±7.81 ml/kg/min) and a significantly lower explained variance (R^2 = 0.41). Tethered swimming showed good reliability (ICC: 0.81). The tested methods ranked from most to least practical were cycling, arm-cranking, ergometer swimming, and tethered swimming.

Conclusions Both the cycling and tethered swimming tests demonstrated high validity with comparable $\dot{V}O_{2max}$ values, indicating their effectiveness in assessing endurance capacity. Whereas the tethered swimming allows for sport-specific measurements, the cycling test is more practical and has previously shown better test-retest reliability.

KEY WORDS: $\dot{V}O_{2max}$, cycling, arm crank, swim ergometer, tethered swimming, endurance performance

Poster 19

THE OPTIMAL MATCH BETWEEN CHILD AND WHEELCHAIR (OPTIMA): POTENTIAL AND INHIBITING FACTORS OF THE PROCESS OF PROVIDING PEDIATRIC WHEELCHAIRS

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Introduction: Approximately 5000 children in the Netherlands use manually operated wheelchairs for their daily mobility. However, it appears that current used wheelchairs are often unfit for children. They are either too heavy, too unwieldy, or fail to adequately meet the child's needs to participate in daily life (Sol et al., 2021). Moreover, the process of acquiring an optimal wheelchair is complex and time-consuming, involving many different stakeholders in the process of application procedure (Gowran et al., 2021).
Purpose: The aim of this study is to gain insight into the potential and inhibiting factors of the process of providing pediatric wheelchairs.
Method: First a qualitative study with focus groups was conducted for each stakeholder: parents, children (12-17 yrs), WMO- consultants, wheelchair suppliers and manufacturers, physiotherapists and occupational therapists. All experiences of each stakeholder were shared and mapped these in each step of the procedure, illustrated in Figure 1. For data analysis, a deductive analytic approach was used (Gale et al., 2013).
Results: This study revealed that among others: 1) the long-time frame of the application process and 2) the continuous monitoring the changing anthropometry of the growing children to match an optimal wheelchair were the themes for the follow up questionnaire.
Conclusions: The growth of a child complicates the process of requesting and finding a properly fitting pediatric wheelchair. Moreover, the combination of factors such as different priorities among various stakeholders, challenging collaboration among stakeholders, the lack of appropriate knowledge and expertise among the involved parties as well as the differences in contractual agreements between municipalities and wheelchair suppliers will lead to a long-time span and an inadequate wheelchair. At least, more assertive parents and children appear to be more successful in advocating for a suitable (new) pediatric wheelchair. The following questionnaire will focus on these main themes.

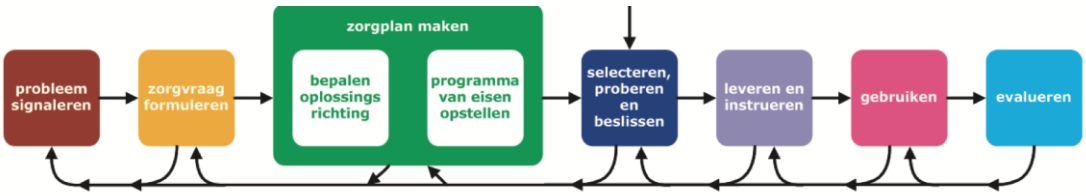

Figure 1: process for acquiring a wheelchair (from *www.nictiz.nl, Den Haag 2015*)

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Poster 20

Title: EFFECT OF INTERNAL, EXTERNAL, AND HOLISTIC FOCUS OF ATTENTION ON PUNCHING PERFORMANCE WITH PREFERRED AND NON-PREFERRED HAND

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Abstract

Introduction

Studies consistently show an advantage of external focus of attention (directing attention to the movement outcome) over internal (directing attention to movement execution), and there is growing evidence that a holistic focus of attention (directing attention to overall feeling) induces superior performance over an internal focus. However, the evidence is equivocal with respect to degree to which these attentional focus effects relate to movement automaticity.

Purpose

This study investigated the degree to which difference in the effects of external, internal and holistic focus of attention relates to movement automaticity by comparing performance between the preferred and non-preferred hand in a karate punching task.

Method

13 experienced karate players completed karate reverse punches (i.e., gyaku-zuki) on a boxing bag with internal, external and holistic focus of attention instruction using both their preferred and non-preferred hands.

Results

Results confirmed the advantage of external focus of attention relative to internal focus of attention. In addition, for peak wrist velocity this differential attentional focus effect only occurred in the preferred hand. For impact force, no difference of attentional focus was found between the two hands.

Conclusion

We argue that these observations are consistent with the constrained-action hypothesis, which implies that external focus of attention delivers superior performance compared to internal focus of attention when movement control is (more) automatized, as per preferred hand.

Poster 21

A DIGITAL RUNNING COACH FOR GUIDED RUNNING-STYLE EXPLORATION AND FEEDBACK IS BOTH TECHNOLOGICALLY AND CONCEPTUALLY FEASIBLE

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Introduction In recent years, the development of wearable systems and their use by runners has taken a leap forward. Among these, instrumented wireless earbuds form a promising emerging technology, for which we are developing a digital running coach, which guides runners through various running styles based on the principle of learning through exploration. Different runners exhibit different running styles at a certain speed, which according to the dual-axis model can be comprehensively described using just two variables: cadence and duty factor (reflecting the stance-to-flight-time ratio). The envisioned digital running coach will 1) drive runners through different running styles by modulating the cadence (through acoustic pacing) and/or duty factor (through instructions about stance or flight time) and 2) provide feedback about the performed running styles by parameterizing cadence and duty factor from earbud data.

Purpose The aim of this research is to examine the technological and conceptual feasibility of such a digital running coach.

Methods To assess the technological feasibility of the digital running coach, we analysed the reliability and concurrent validity for cadence and duty factor variables derived from earbud data. As regards its conceptual feasibility, we compared and analysed the effectiveness of various forms of acoustic pacing and different verbal instructions to modulate these variables.

Results Cadence and duty factor can both be reliably and validly derived from instrumented wireless earbuds. Cadence can be modulated best with step-based acoustic pacing, without adversely affecting the impact force. Duty factor can be modulated with verbal instructions about changing stance time as well as flight time.

Conclusions We conclude that the envisioned digital running coach, providing runners feedback about their running style and guiding them through different running styles, is technologically and conceptually feasible. Based on these findings, a guided exploration protocol which instructs runners to explore the different running styles of the dual-axis model can be implemented in the instrumented wireless earbuds to create the first iteration of a digital running coach.

Poster 22

ARE INDIVIDUAL ADAPTATIONS FOR SPRINT AND ENDURANCE PERFORMANCE RELATED TO CHANGES IN MUSCLE MORPHOLOGY FOLLOWING CONCURRENT TRAINING?

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Introduction: Many sports require a combination of high sprint and endurance performance. Previously, it was shown that quadriceps muscles consisting of long fascicles - rather than a large physiological cross-sectional area (PCSA) - were beneficial for combining sprint and endurance cycling performance.

Purpose: To determine how 12 weeks of concurrent strength and endurance training changes muscle morphology of the vastus lateralis (VL) in cyclists. And investigate whether changes in (combined) sprint and endurance performance are related to changes in muscle morphology.

Method: Twenty recreational cyclists, divided into four training groups, completed an individualized 12-week training intervention consisting of five training sessions per week. A control group performed low-intensity endurance training and a polarized group performed endurance + interval training. A concurrent group combined polarized endurance and concentric strength training. Another concurrent group combined polarized endurance and eccentric strength training. Before and after the training intervention, the following measurements were taken: VL muscle morphology by three-dimensional ultrasound imaging, peak power (PO_{max}) during 30-s Wingate test, $\dot{V}O_{2max}$ from maximal incremental exercise test and finish time of 4-km cycling time trial (TT_{time}). Muscle volume, maximal anatomical cross-sectional area ($ACSA_{max}$), fascicle length (L_f), pennation angle and PCSA were derived from the 3D images. PO_{max}, $\dot{V}O_{2max}$ and TT_{time} reflected performance for sprint, endurance and combined sprint and endurance, respectively.

Results: At baseline, performance outcomes were positively related to muscle volume, $ACSA_{max}$ and L_f ($r=0.22$-0.75, $p<0.05$). Large variations were shown in individual changes in muscle morphology (-38 to 46%) and performance outcomes (-9 to 21%). At group level, mean changes did not differ between the four training groups ($p>0.05$). In addition, changes in muscle morphology and changes in performance were not shown to be significantly correlated (r between -0.65 and 0.56, $p>0.05$).

Conclusions: Here we show in recreational cyclists that sprint and endurance performance are related to VL morphology. However, 12 weeks of different concurrent training modalities induces variable, individual differences in muscle morphological and performance measures, but these were not related. These data suggest that training induced changes in sprint and/or endurance performance of recreational cyclists are explained by determinants other than changes in VL muscle morphology.

Poster 23

UNCOVERING DETERMINANTS OF TRAINING ADAPTATION IN RECREATIONAL CYCLISTS: WHAT CAN WE LEARN FROM MACHINE LEARNING?

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Introduction: Training adaptations largely differ between individuals even though they may receive the same training stimulus. The complex effect of training adaptation increases when endurance and strength training are combined, although combining these training modalities is required for several sports such as a 4-km time-trial in cycling. Machine learning techniques can be used to uncover determinants of training adaptation.
Purpose: The aim of this study is to model individual adaptations in cycling performance after a 12-week training intervention using machine learning and to uncover critical predictors for these adaptations.
Methods: 19 participants (17 male, 2 female) performed a 4-km time-trial, Wingate test, $\dot{V}O_{2max}$-test, 3-dimensional ultrasound measurement of the vastus lateralis muscle, jump test and $\dot{V}O_2$ -kinetics test. After which the participants were divided into four training groups and completed a 12-week training intervention of five sessions per week. A control group (CON, n=6) performed only low intensity (zone 1) training sessions, a polarized group (POL, n=5) performed where the training intensity distribution was polarized. One concurrent training group (CT1, n=4) performed three endurance sessions using the same polarized intensity distribution as POL with an additional two concentric strength training per week. Another concurrent training group (CT2, n=4) performed the same training as CT1, but with eccentric strength. Participants logged their wellness using a daily questionnaire. A random forest model and a generalized linear model were used to predict change in time-trial performance and were compared to a naïve baseline model. Performance of each model was obtained using the root-mean-squared error (RMSE).
Results: Group-based differences in 4-km time-trial performance were not significant ($p>0.05$), but mean individual change in performance was significantly different from 0% and ranged from -1.79% to + 3.95% ($p<0.05$). Best performing model was the random forest model, which had a RMSE of 1.14% and performed 22% better than the naïve baseline model.
Conclusions: Machine learning models were able to outperform a baseline model in predicting individual training adaptation. Important determinants in the random forest model include well-being, training impulse and pre-intervention features. Curious to which exact features influence predictions in adaptation? Come and check out my poster!

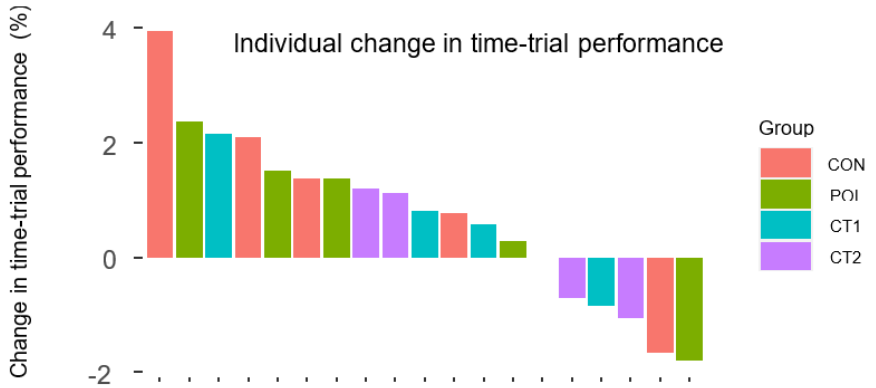

Figure 1: Individual changes in 4km time-trial performance. Each bar represents an individual and colours indiate group allocation. For abbreviations see text.

Poster 24

TOWARDS A TOOL-KIT FOR ASSESSING MENTAL FATIGUE AND ITS EFFECTS ON MOVEMENT

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Introduction Mental fatigue (MF) can adversely affect the planning and execution of a broad variety of tasks, including perceptual-motor tasks. However, the influence of MF on movement is difficult to assess because (1) no established objective measures are available for measuring MF, and (2) the effects of mental fatigue on the planning and control of perceptual-motor tasks may be subtle.
Purpose The overarching aim of the presented research is to develop and validate a tool-kit for the assessment of MF which can be employed in applied settings, including sports. In the first study we examined the hypothesis that the influence of MF on balance control depends on the attentional effort required by the balance tasks being performed, thus gaining experience with the induction and assessment of MF. A follow-up study is planned to determine the best task to induce MF, which will then be used to identify objective measures for validly assessing MF.
Method In the first study, 44 young adults performed six balance tasks with different attentional requirements before and after an intervention, which either consisted of performing the TLoadDBack task to induce MF or watching a documentary. Balance task performance was assessed objectively based on the characteristics of simultaneously recorded center-of-pressure (COP) time-series. In the follow-up study, the efficacy of different tasks for inducing MF with different durations will be compared to determine the most suitable one, which will then be used in an experiment involving many objective measures, including electroencephalogram, eye tracking, heart rate, skin conductance, and a face reader, to determine which of those are suitable predictors of MF.
Results In the first study, MF was found to have only marginal effects on balance control in healthy young adults, even though both the balance task manipulation and the interventions were effective. A protocol is available for the follow-up study.
Conclusions MF has only marginal effects on static balance control in healthy young adults, indicating that in this population postural control is largely automatic. When the tool-kit for the objective assessment of MF is available, deeper insights can be gained into the effect of MF on movement.

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TO PUSH OR TO BE PUSHED, THAT'S THE QUESTION IN WHEELCHAIR MOBILITY

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Introduction: An active lifestyle is important to maintain good health, even more in people that are wheelchair-bound. To measure physical behaviour for rehabilitation research and healthcare applications, it is important to have an easy-to-use and accurate method to distinguish between active or passive wheelchair use. **Purpose:** To construct a new algorithm for detection of active or passive wheelchair propulsion, based on inertial measurement unit (IMU) sensors in patients with stroke or amputation in a clinical rehabilitation setting. **Method:** Twelve amputation patients and twelve CVA patients performed a free course and a set of standard tests in their own wheelchair at the rehabilitation centre (Basalt in The Hague) in which they were pushed of propelled themselves. Movesense IMU's attached to the wheel and frame of the wheelchair were used for data collection. Data was split into distinct segments of forward movement with a segment consisting of all consecutive timepoints with a wheelchair speed above 0.1 m/s. Each segment was classified as active or passive propulsion based on manual annotation. Two binary classification models were constructed to distinguish between active or passive propulsion. The *wheel model* solely relies on predictor variables based on the data from the sensor placed at the wheel and the *full model* includes predictor variables constructed from both sensors. **Results:** Models perform well (F1 scores > 0.8), with the full model slightly outperforming the wheel model (see Table 1). The standard deviation in the linear speed of the wheelchair is the most important predictor of our classifier. **Conclusions:** The IMU based measurements with only wheelchair mounted sensors is an accurate and easy-to-use method for monitoring activity for wheelchair bound patients in a clinical rehabilitation setting. The method could be of great value for fundamental research, invention studies, and optimization of rehabilitation treatment.

Table 1. Average performance of the wheel and full models on the test set across 25 different random splits of the total data.

	Accuracy	**Precision**	**Recall**	**F1 Score**
Wheel model	0.813	0.827	0.838	0.831
Full model	0.870	0.899	0.876	0.886

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TOWARDS AN AUTOMATED FEEDBACK SYSTEM FOR OPTIMIZING FREESTYLE SWIMMING TURNS: INTEGRATING VIDEO AND FORCE DATA WITH MACHINE LEARNING

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Introduction

Augmented feedback has emerged as a powerful tool for enhancing athletic performance in sports, including swimming. The freestyle swimming turn is a critical phase where swimmers can gain a competitive edge by optimizing their turning technique, which might be facilitated with an automated feedback system.

Purpose

This project aims to develop a feedback system that integrates synchronized video footage, data collected with a vertically mounted Kistler force plate, and machine learning algorithms to automate the calculation and analysis of key performance variables related to the swimming turn. The ultimate objective is to provide real-time augmented feedback, enabling swimmers and coaches to assess and improve turning performance.

Method

The feedback system utilizes synchronized video footage from two cameras and force plate data. Mediapipe's machine learning algorithm is employed to detect and track body segments, including the swimmer's center of mass. Real-world coordinates are calculated for the purpose of spatial and temporal analysis. The system generates a video overlay displaying the swimmer's center of mass and the exerted force vector during the turn.

Expected results

By automating the analysis of data from multiple input sources using machine learning the developed system can determine key performance variables (such as the exit velocity and the alignment of force and velocity vectors) and significantly reduce the analysis time. With this enhanced data gathering capacity, insights will be gained into how to maximize the effectiveness of the push-off force. These findings will be presented visually to the swimmers/coach, providing them with instantaneous evidence-based augmented feedback (figure 1).

Conclusions

The feedback system being developed offers automated analysis of freestyle swimming turns. By integrating multiple input sources and leveraging machine learning, it eliminates the need for manual determination of key performance variables. Real-time visualization of the swimmer's center of mass and displayed force vectors provide valuable augmented feedback, streamlining analysis processes and offering opportunities for time gains and improved performance. This system has the potential to revolutionize swimming analysis and training to the benefit of both coaches and swimmers.

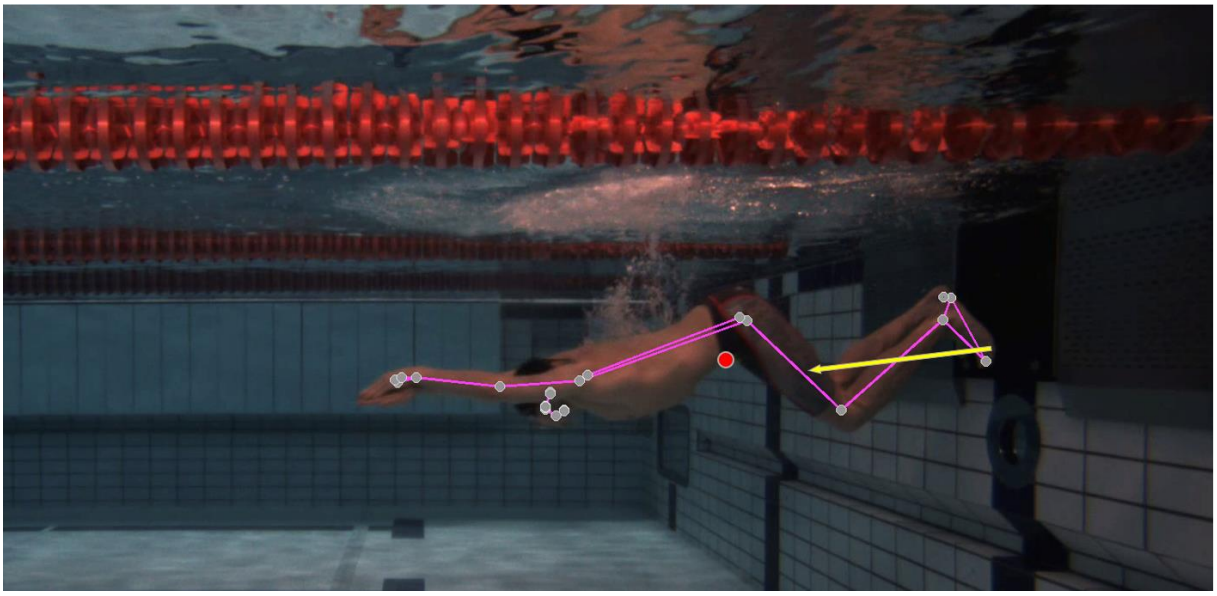

Figure 1.example of the graphical representation of the system in action, displaying the swimmers body segments, center of mass and push-off force and direction (length of the arrow and direction of the arrow respectively). Body segments and COM are all tracked using markerless tracking.

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MUSCLE LOAD FEEDBACK DURING STRENGTH TRAINING

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Introduction
Strength training (ST) athletes are at risk for injuries, especially at their muscles and tendons (59% of all injuries) [1]. The most common injury cause mentioned by strength training athletes is overload [1]. Muscle overload may be prevented if strength training athletes receive feedback regarding their personal muscle load during their workout.

Purpose
The objective of this study was to assess if a muscle load feedback application could aid ST participants in achieving a more balanced muscle load during their workouts.

Methods
Thirty healthy participants were randomly allocated over three groups: control, 'partial feedback' and 'full feedback'. The one-repetition maximum (1RM) of all participants was estimated for 18 exercises [3]. All participants performed eight ST sessions, wherein they were instructed to perform eight exercises of their choice, while attempting to load all muscles evenly. Performed exercises, sets, repetitions, and weights were tracked by the Gymstory sensor and app [4]. Based on these data combined with the 1RM's and anatomical knowledge of muscle contributions, the cumulative muscle load of participants was estimated. The feedback groups received a visualization of this estimation as a muscle load body map, while the control group did not. The 'full feedback' group additionally received a list with suggestions for next exercises, targeting muscles that had not or barely been loaded. The muscle load standard deviation (STD) per session was used as indicator of muscle load balance and compared between groups and workouts using Generalized Estimation Equations.

Results
The 'full feedback' group had a significantly lower muscle load STD compared to the control group ($p<0.001$) and the 'partial feedback' group ($p=0.038$). There was no significant effect of workout number or interaction.

Conclusions
ST athletes who receive feedback including a personalized muscle body map and next exercise suggestions can achieve a more balanced (estimated) muscle load in their workout. This application can provide ST athletes with more insight into their individual muscle load and may potentially aid in preventing muscle overload injuries. Future research should focus on improving the accuracy of the muscle load feedback by measuring actual muscle loads on-site instead of using anatomical estimations.

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