BIOMECHANICS IN THE 4HAIE STUDY: AIR POLLUTION AND MUSCULOSKELETAL HEALTH - AN UPDATE

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The overall purpose of the 4HAIE study was to assess the influence of the interaction between air pollution and biomechanical, physiological and psychosocial factors on the incidence of injuries, health and well-being. A total of 1,500 active runners and inactive controls aged 18-65 will be recruited. Herein, we describe the biomechanical study design with data examples to investigate musculoskeletal and neuro-mechanics health in different air quality regions.

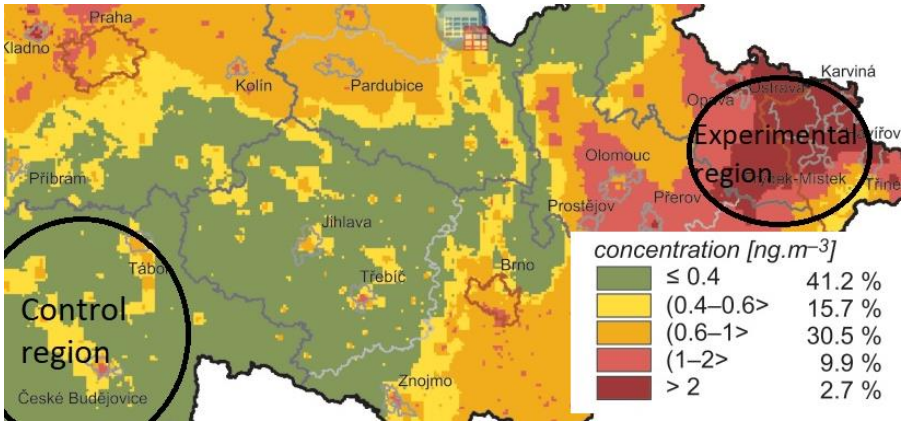
KEYWORDS: aging, running, walking, cutting, ACL, Achilles tendon, cartilage

INTRODUCTION: A significant proportion of the active population is exposed to air pollution especially in large cities. Air pollutants have been proven to reduce life expectancy and induce respiratory, cardiovascular, cancer, lung and brain, diabetes and dementia diseases in adults and children (Peters et al., 2017; Sram et al., 2013). In contrast with the air pollution effect, running as exercise has been reported to reduce the risk of cardiovascular, cancer, metabolic, mental and neurodegenerative diseases (Lee et al., 2017). Despite the increasing trend of air pollution, nearly 30% of males and 20% of females aged 18-29 participate in running exercise. However, less than 2% of males and less than 0.7% females continue to run past 65 years of age (Dai et al., 2015). The first purpose of 4HAIE study will assess the influence of the physical activity and air pollution on the incidence of running related injuries and musculoskeletal health status across different ages of an active and inactive sample living in air polluted and unpolluted control regions.
Previous investigations showed that air pollution is associated with decrease in neurobehavioral functions and levels of gross and fine motor skills (Lin et al., 2014; Wang et al., 2009). Decreased reaction times, processing speed, or visual spatial disorientation may expose individuals to anterior cruciate ligament (ACL) injurious situations by disrupting the neuromuscular control necessary for dynamic restraint (Swanik, Covassin, Stearne, & Schatz, 2007). Biomechanics and dynamical systems approaches may provide greater insight into the state of the system (i.e. individual, environment and task) by assessing the complex interactions between segments, joints and neurocognitive function during dynamic movement task such as cutting (Hamill, van Emmerik, Heiderscheit, & Li, 1999). Therefore, the second purpose of 4HAIE study will assess biomechanical risk factors of ACL injury, coordination

variability during cutting manoeuvres and quality of ACL tissue using MRI images across age groups in relation to their environment.
Walking for active transportation provides substantial health benefits from increased physical activity (PA) (Mueller et al., 2015). However, active travel may increase the intake of air pollutants, leading to negative health consequences (Tainio et al., 2016). Pollution from traffic is one of environmental risk factor for rheumatoid arthritis (RA) (Hart, Laden, Puett, Costenbader, & Karlson, 2009). Increased risk of RA in participants exposed of PM2.5 and NO2 was detect in retrospective study on the Taiwan (Chang et al., 2016). Therefore, the third purpose of 4HAIE study will investigate effect of air pollution on cartilage quality of active and inactive participants living in air polluted and unpolluted control regions across age and sex groups.

METHODS: A total of 1,500 participants aged 18-65 years will be recruited for this study. Of these, 900 will be physically active runners and 600 inactive controls. The runners and inactive controls will be split evenly between two regions: the experimental highly-polluted industrial region and the control low-pollution level region (Figure 1).

Figure 1. Field of annual average concentration of benzoapyrene at 2018 year. (CHMI, 2018)**.**



Participants will be screened by online questionnaires and undergo two days of baseline laboratory assessments including biomechanical, physiological, psychological testing and magnetic resonance imaging. Participants will be monitored for one year after the two-day baseline testing. During this year, online physical activity data, data on incidence of injuries, air pollution to which they are exposed, and questionnaires on their behaviour and feelings will be recorded. Data collection was started in 2019 and will be completed by 2021. Follow up data collection is scheduled for 2024 and will be completed by 2026.

RESULTS and DISCUSSION: To date, we have managed to recruit and measure 540 participants (Table 1). Figure 2 shows an example of biomechanics data. Figure 3 illustrates MRI quantitative data from knee cartilage, ACL and Achilles tendon. Knee cartilage T2 relaxation time (T2*) mapping is sensitive to cartilage damage and quality of cartilage collagen and hydration (Nieminen, Casula, Nevalainen, & Saarakkala, 2019). Individuals with an increase in medial knee loading (knee abduction moments) have shown an increase in medial knee relaxation times (Kumar et al., 2018). Quantitative ACL T2 relaxation time has potential for non-invasive identification of ACL degeneration (Schmitz, J et al., 2018). A shorter T2* component correlates strongly with clinical score of the Achilles tendon degeneration (Juras et al., 2013).

CONCLUSION: Herein we introduce MRI imaging and biomechanical study design and data examples to investigate musculoskeletal and neuro-mechanics health in this 4HAIE cohort including the design for control of physiological and psychological injury factors. In the current ongoing research project, we hypothesized that there will be interactions of biomechanical, physiological and psychosocial variables and these interactions will cause musculoskeletal diseases/protection especially in the highly-polluted industrial region compared to the unpolluted control region. The biomechanics community, ISBS members and PhD students

are welcome to co-participate in 4HAIE project and submit proposals for use of the data at data4haie@osu.cz.

Table 1: Current 4HAIE recruitment and stratification (January 2020). In total, 540 participants have been recruited (405 runners and 135 inactive controls).

Regions	Age Groups	Groups		Total
		Runners	Inactive	
Air unpolluted region	18-25	18	12	30
	26-35	23	16	39
	36-45	71	15	86
	46-55	28	15	43
	56-65	7	6	13
	Total	**147**	**64**	**211**
Air polluted region	18-25	20	5	25
	26-35	64	19	83
	36-45	110	25	135
	46-55	61	16	77
	56-65	3	6	9
	Total	**258**	**71**	**329**

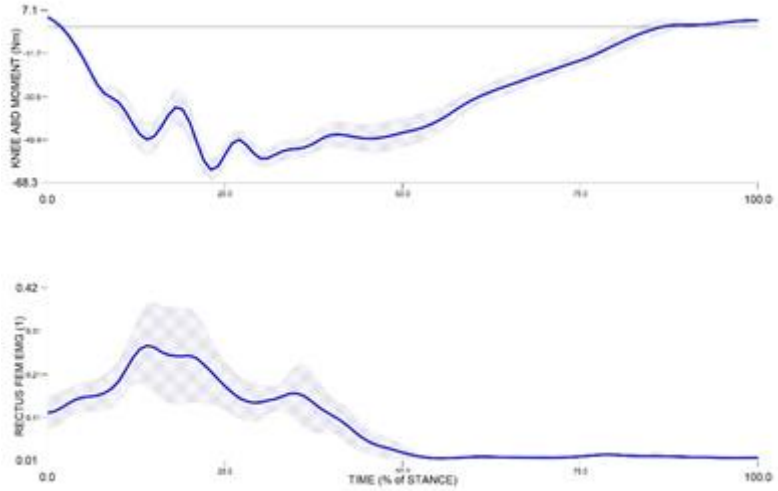


Figure 2: Knee abduction moment and rectus femoris EMG during stance phase of self-selected speed overground running of one runner (8 trials mean ± SD).

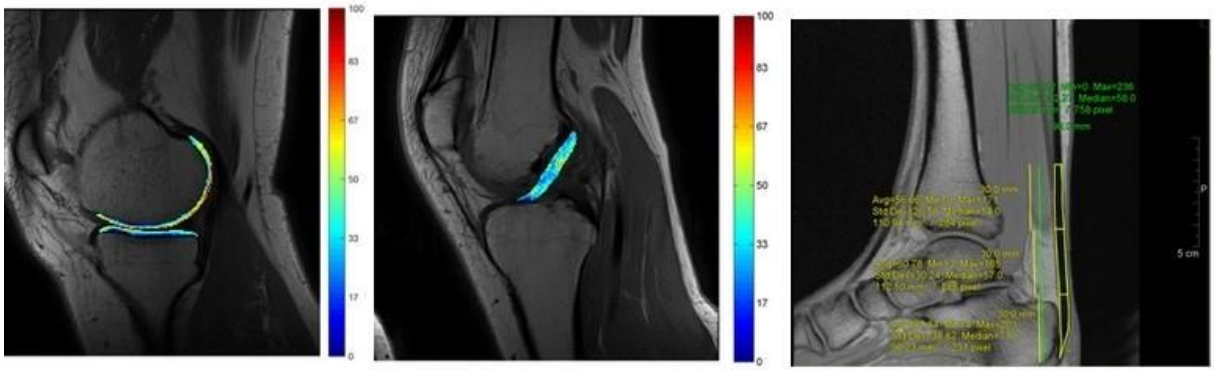


Figure 3: Representative quantitative magnetic resonance image T2 maps of knee cartilage (left) and ACL (middle), and T2* map of the Achilles tendon (right).

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