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Rapport fra et prosjekt med datainnsamling under Forskningsdagene 2012

Giovanna Calogiuri

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Trening ute eller inne?

Rapport fra et prosjekt med datainnsamling under Forskningsdagene 2012

Reciprocal benefits of physical activity and exposure to nature for greater gain in health promotion.

Theoretical assumptions and description of a pilot study.

Prosjektleder: Giovanna Calogiuri
Universitetet for Miljø- og Biovitenskap

Medarbeidere:

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Katinka Horgen, Ruth Kjærsti Raanaas, Grete Grindal Patil & Camilla Martha Ihlebæk	**Universitetet for Miljø- og Biovitenskap**

FORORD

Våren 2012 ønsket Alta kommune ved prosjketleder for Sykkelbyen Alta, Gjermund Abrahamsen Wik, å se på fordelene ved å sykle til jobben. Post. doc ved Universitet for Miljø- og Biovitenskap (UMB), tidligere prosjektmedarbeider ved Høgskolen i Finnmark Dr. Giovanna Calogiuri, var interessert i om utendørsaktivitet hadde positive tilleggseffekter for helsa sammenliknet med innendørsaktivitet. Begge luftet sine intersser for meg, samtidig med at planleggingen av Forskningsdagene 2012 var i startfasen. Kolleger og forskningsnettverk ble aktivisert og prosjektet med arbeidstittel "sykle ut-sykle inne?" var en realitet.

Foreliggende rapport er ikke bare en rapport fra gjennomføringen og resultater av det som skjedde under Forskningsdagene 2012, men også den teoretiske bakgrunnen for antakelsene om at det gir større helsefordeler ved å gjennomføre aktivitet ute, sammenliknet med innendørs.

Prosjektet som ble gjennomført under Forskningsdagene 2012, var et pilotprosjekt som bidrog til stort engasjement fra forskere fra både UMB, HiF og UiT og har stort potensiale for fortsatt forskningssamarbeid mellom instusjonene, særlig når HiF og UiT fusjonerer til UiT-Norges Arktiske Universitet.

Jeg ønsker å takke alle som bidrog med støtte og entusiasme før, under og etter Forskningsdagen. Spesielt takkes initiativtakerne og deltakerne for alle dataene de bidro med, men også forskningskolleger som kom med tips og gode bidrag i alle faser av prosjktet.

Jeg håper rapporten fra pilotprosjektet gir leserne noen tanker om nødvendighet av natur og grønne lunger omkring oss, og at vi og andre kan jobbe med mer med problemstillingene som inngår i pilotprosjektet slik at de aktuelle forhold blir bedre kartlagt.

Alta 13.mai 2013

Andi Weydahl

PREFACE

Spring 2012 the leader for the project “Bicycle City Alta”, Gjermund Abrahamsen Wik, wanted to look at the benefits of cycling to work. Post doc at the Norwegian University of Life Science (UMB), former project coordinator at Finnmark University College (HiF) Dr. Giovanna Calogiuri, was interested to study the effect of outdoor activity compared to indoor activity, to see if outdoor activity had health effects above and beyond compared to indoor activity. Both aimed their interest for me, when the planning of National Science Week 2012 was starting. Colleagues and research network was activated and the project with the working title "cycle outside or inside?" was a reality.

The present report is not just a report of the implementation and results of what happened during Science Week 2012, but it gives the theoretical background for the assumptions that outdoor activity will give greater health benefits compared to indoor activity.

The project, completed during Science Week 2012, was a pilot project showing large involvement of researchers from UMB, HiF and University of Tromsø (UiT) and seems to have potential for continued research collaboration between the institutions, especially when HiF and UiT merge into UiT – The Arctic University of Norway.

I want to thank everyone who helped with support and enthusiasm before, during and after the Science Week. Thanks especially to participants for all the data they contributed with, but also to colleagues who came with hints and contributions during all phases of the project.

I hope this report from the pilot project gives the readers some thoughts upon the necessity of nature and green spaces around us, and that we and others can continue the work with the topics included in the pilot project.

Alta May 13th 2013

Andi Weydahl

Index

SECTION I

INTRODUCTION

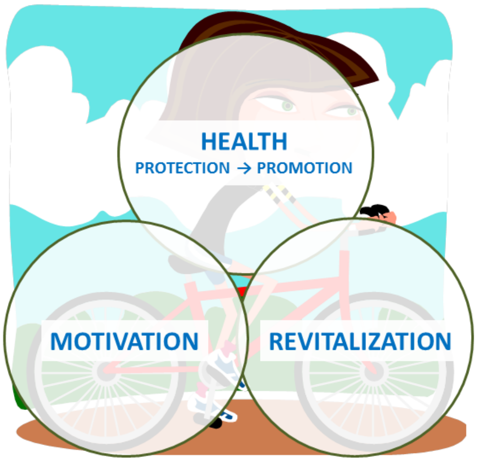
1.1 Rationale and Scope of the Project

Recent studies have highlighted that health problems connected to inactivity are not just associated to lack of exercise, but rather to sedentary behaviour in a broader sense. In a large longitudinal study in the U.S.A., it was found that the amount of time spent in sedentary behaviour, such as watching television, was associated with cause-specific mortality in normal adults, even in subjects who did engage in some exercise program including intensive physical activity PA (Matthews et al., 2012).Therefore, in health promotion, it is important to promote active lifestyles characterized by higher activity levels across the day, increasing the time and frequency one is engage in any body movement, rather than only promoting participation in exercise sessions taking place two or three times a week.

It has been suggested that protecting and promoting access to urban quality-green spaces may improve people activity rates, both providing opportunities for exercise, leisure activities and active transport (A. C. K. Lee & Maheswaran, 2011). Moreover, it has been reported that PA in contact with nature (*PAnat*) elicits revitalization and positive mental states above and beyond PA taking place elsewhere, e.g. in 'traditional' indoor settings (*PAind*) (Mitchell, 2012; Ryan et al., 2010; Thompson Coon et al., 2011), and this may act as a motivational booster making people embrace active lifestyles. It has also been reported that PAnat, such as walking in natural environments, have positive effects on cognitive performance (Hartig, Mang, & Evans, 1991) and indicators of psycho-physiological and physical health (i.e. stress hormones, metabolic parameters and immune resources (Li, 2010)).

Another problem connected with PA and health, is the 'overexposure' to *indoor-living*: in modern urbanized life, many individuals work and live inside, therefore spending most of the day, in buildings provided of artificial illumination and heating. Although these life conditions provide human species with a number of advantages, yet it presents health challenges such as thermoregulation deficits, vitamin D deficiency and 'light pollution' (exposure to artificial light late in the day), which may threaten individuals' physiological functions as well as mental states in the long term (Hahn et al., 2011; Holick, 2008a; Kloog, Portnov, Rennert, & Haim, 2011). Participating in PA in indoor settings, such as in gym-halls, contribute to the permanence of 'overexposure' to indoor-life conditions. On the contrary, participation in PA in outdoor settings provides people with more opportunities to spend time outdoors, exposed to fresh air and natural daylight.

This report gives a narrative review of literature integrating theories and findings concerning the health 'advantages' of PAnat as compared to PA in indoor or urban settings. The rationale and preliminary results of an exploratory study investigating psychological and physiological indicators of health in connection with participation in a PAnat vs. PAind exercise intervention will be also presented.



The theoretical fundament of this report are constructed on a triple-focus model, wherein psychophysiological effects experienced in contact with nature sustain behavioural attitudes and motivation to embrace active lifestyles, with positive gains for mental and physical health.

1.2 The research project: a pilot study.

The pilot study was designed on a triple focus: **Mo**tivation, **Re**vitalization and biomarkers of **Health** (***MoReHealth***).
These three integrated research perspectives aims to investigate

a. the impact of proposing PAnat experiences in promoting active lifestyles, and
b. Further benefits on mental and physical health elicited by PAnat.

In the following chapters, it will be highlighted how these two perspectives are tightly interconnected, possibly leading to mechanisms that protect and promote peoples health

Motivation
Effects of nature improving motivation to embrace an active lifestyle

Revitalization
Effects of nature improving mental health profiles

Health
Impact of nature on biomarkers of health

MoRe Health

At the Norwegian University of Life Science (*Universitet for Miljø- og Biovitenskap*, UMB), the Section for Public Health Science (FOHE. Department for Landscape Architecture and Spatial Planning) has a multidisciplinary focus of the health benefits of nature, natural elements and activities in contact with nature. The FOHE has produced a number of studies on different issues concerning the health benefits of exposure to natural elements and activities in contact with nature, such as therapeutic horticulture, benefits of foliage-plants in indoor settings and influences of neighbourhood quality on quality of life (Bringslimark, Hartig, & Patil, 2007, 2009, 2011; Gonzalez, Hartig, Patil, Martinsen, & Kirkevold, 2009, 2010, 2011a, 2011b; Raanaas, Evensen, Rich, Sjostrom, & Patil, 2011; Raanaas, Patil, & Hartig, 2010, 2012). On the direction indicated by two main documents released in 2009, the '*Nordic Action Plan for better health and quality of life through nutrition and PA*' and the '*Nordic Environmental Action plan 2009-2012*', the FOHE established a strategic action plan for *Friluftsliv*, or outdoor activities on mental and physical health. Within the Friluftsliv plan, it has been established a Post-doctoral position on the "*The importance of the environment, nature and nature elements for health promoting experiences and activities*".

Researchers at Institute for sport sciences at Finnmark University College (HiF) have been engaged in several international research projects looking at the effect of natural phenomena, such as darkness periods, midnight sun and geomagnetic storms, upon the human organism and performance (Calogiuri & Weydahl, 2013; Calogiuri, Weydahl, & Sothern, 2011; Calogiuri et al., 2009; Calogiuri, Weydahl, Beldo, & Montaruli, 2010; Oinuma et al., 2002; Otsuka, Cornelissen, et al., 2001; Otsuka, Oinuma, et al., 2001; A Weydahl, Rb, G, & L, 2001; A. Weydahl, R. B. Sothern, & L. Wetterberg, 1998; A Weydahl & Sothern, 1997, 1998; A. Weydahl, R. Sothern, & L. Wetterberg, 1998; A. Weydahl, 1990, 1991a, 1991b, 1994; A. Weydahl, Balto, Einvik, Mikkelsen, & Sothern, 1995; A. Weydahl, Sothern, & Cornelissen, 2002; Andi Weydahl, 2005) .
In 2012, UMB and HiF collaborated realizing a pilot study that aimed to investigate mental and physical health parameters in school and municipality employees' following a PA-based intervention in two different environmental settings: a 'traditional' exercise environment (indoors in a gym-hall) and a green area surrounding the HiF Campus. A number of psychological and physiological parameters were measured before, during and after the intervention, in order to study possible benefits of PAnat beyond PAind conditions.

Research questions:

1. Does PAnat elicit greater positive subjective experiences of PA and affective responses to exercise, positively impacting future motivation to exercise?
2. Does PAnat promote restoration from mental fatigue and stress, improving the profile of biomarkers of psycho-physiological stress?
3. Does exercising outdoors, exposed to natural daylight, increase the melatonin production, improving the stability of the circadian structure?
4. Does exercising outdoors, exposed to sunlight, contribute to higher systemic levels of vitamin D?

Hypothesis:

Research question 1

Compared to the 'traditional' indoor exercise setting (PAind), the exercise-intervention outdoors in contact with nature (PAnat) will:

1. Be associated with better subjective experiences of PA (lower perceived exertion and greater enjoyment) and greater positive affective response to exercise;
2. Positively impact motivation to engage in PA, with higher ratings of intention to exercise in future and improved behavioural attitude toward PA;
3. Lead to increased post-intervention ratings of PA.

Research question 2

4. As compared to the PAind setting, the PAnat setting will be assigned of greater *restorative qualities*;
5. Compared to the PAind, PAnat will be associated with greater reduction of fatigue post-exercise;
6. Participating in the PAnat will be associated with improved profile of indicators of psycho-physiological stress (i.e. cortisol release and autonomic cardiovascular control);

Research question 3

7. Participation in outdoor PA will be associated with increased nocturnal MLT production, which will be on turn associated to enhancement of sleep-wake patterns.

Research question 4

8. Participation in outdoor PA will be associated with improved vitamin D status.

SECTION II

THEORETICAL BACKGROUND

2 Motivation: Nature promoting physical activity and active lifestyles

2.1 Motivation to exercise

It has been reported that potential health improvements, such as prolonging life and increasing its quality, are the major factor motivating individuals to commit to exercise (Godin, Shephard, & Colantonio, 1986). Another important motivational factor is the 'feeling-good' effect (Biddle & Mutrie, 2008). On the other hand, inactive individuals tend to recognize fewer benefits to exercise and invoke 'fatigue' as an important limitation to engage in exercise (Ontario Ministry of Tourism and Recreation, 1981). A large portion of the population do recognise the importance of being physically active and have positive intention to engage in an exercise program, but yet remain mostly inactive or do not engage in exercise on a regular base (Godin et al., 1986). While these individuals show cognitive profiles that are surprisingly similar to active individuals, they mostly invoke 'lack of time' and 'fatigue' as main reason for not engaging in an exercise program (Godin et al., 1986). These individulas are a group of high interest when it comes to promotion of physical activities, as they might be more prone to change their behaviour if the right intervention is applied.

The Weinstein & Sandman's *Precaution Adoption Process Model* (PAPM) describe the behaviour change as the subject passing through a set of seven stages that go from being 'unaware of the issue' (not being aware of one's sedentary behaviour and its risks), through the decisional process of weather 'acting or not acting' (deciding to begin being physically active or remain sedentary), up to the stage of ' maintenance' (when one is regularly physically active) (Weinstein, 1988). Before one successfully achieve the stage of maintenance, one has to go through the stage of 'acting', which in this specific case is represented from one's attempt to engage in PA (participating in activities not, or not yet, on a regular base). This is somehow a critical stage: in fact it has been observed that many individuals have positive intention to engage in regularly exercise, and have experienced participation in physical activities, but do not manage to maintain an active lifestyle on a regular base (Godin et al., 1986). Quoting Neil D. Weinstein, "a factor that must be considered is the gap between intentions and action; many people claim to be convinced that a precaution is worthwhile, state that they intend to act, but do not follow through on their intentions".

2.2 Natural environments and possible impact on motivation to exercise

According to Ajzen's *Planned Behaviour Theory*, intention is determined by three components: *attitude to the behaviour*, *subjective norms*, and *perceived behavioural control*. the attitude to the behaviour is not only determined by a *reasoned cognition* (aware, explicit) but also by an unaware component, the *impulsive cognition* (implicit), which on turn is strongly affected by personal experiences (Calitri, Lowe, Eves, & Bennett, 2009; Hartig et al., 1991). The reasoned and the impulsive cognitions can be in accordance or in contrast with each other; in the latter case would explain an intention gap. When it comes to exercise, a big problem is that one may experience discomforts in the acute, such as fatigue and temporary muscular pain, while the benefits of exercising, such as well-being ad 'feeling good', arise with a certain delay after one has been undertaking regular exercise. It could also occurs that environmental factors can negatively impact one's experience of PA, such as poor ventilation, loud music, crowded rooms, feeling embarrassed, difficulties of the tasks, perception of not being adequate for the place and the activity, among others. On the contrary, natural environments represent for many a pleasant environment where to spend time and engage in different types of PA, such as walking, gardening, hiking or exercising. Experiences in natural environment have been found to be associated with positive mental states (Hartig et al., 1991; Ryan et al., 2010; Thompson Coon et al., 2011) and low-intensity activities (such as walking) outdoors were associated to lower perceived exertion and higher ratings of enjoyment, positive affective responses and intention to engage in PA in future, as compared to the same activity undertake indoors on a machine (DaSilva et al., 2010; Focht, 2009; Marsh et al., 2006). These psychosomatic responses to nature can be associated to an immediate sense of wellbeing that makes the experience of PA more pleasant. Such experience may positively impact one's impulsive cognition towards physical activity, sustaining individuals' perseveration and continuing motivation to embrace an active lifestyle. On the other hand, one's love for nature could also be an important motivational factor that elicits active lifestyles. Being in natural environments is often associated with physical activity, although 'sedentary' use of natural environment has been reported as a large component among its users (Bedimo-Rung, Mowen, & Cohen, 2005). individuals who love nature and like to be in natural environments are therefore likely to be more prone to visit them and use it for PA purposes, engaging in activities such as walking, gardening or hiking.

2.3 Green spaces promoting physical activity: a brief overview

A number of research works have shown that access to nature and urban green spaces are associated with health and well-being, and PA has been proposed as an intermediate factor (A. C. K. Lee & Maheswaran, 2011). To date, the majority of the studies indicate that availability of quality green spaces within the living environment is associated with higher rating of PA (Kaczynski & Henderson, 2007; A. C. K. Lee & Maheswaran, 2011), although results appear yet mixed, possibly due to poor quality of some studies. On the other hand, more recent quality studies confirmed the positive association between PA ratings and proximity to green spaces and natural amenities (Coutts, Chapin, Horner, & Taylor, 2013; Michimi & Wimberly, 2012; Mytton, Townsend, Rutter, & Foster, 2012; Ward Thompson, Curl, Aspinall, Alves, & Zuin, 2012).

The availability of green spaces and natural amenities within the living environment might be not 'enough' in order to encourage people in engaging in PA (Bedimo-Rung et al., 2005). Accessibility is an important factor: physical barriers such as traffic-full roads were found to limit visitation of green spaces (C. Lee & Moudon, 2008). while on the contrary ease of access to green spaces were found to predict outdoor activities in older adults (Ward Thompson et al., 2012). Individual characteristics can also be a mediator of use of green spaces. Men were found to use parks more often than women, and more likely to meet minimum recommended levels of PA (Cohen et al., 2007). Also ethnical minorities and people with disabilities have been reported to use less frequently urban green spaces (C. Lee & Moudon, 2008). Qualitative characteristics of the environment itself, such as safety (Cervero & Duncan, 2003; Hillsdon, Lawlor, Ebrahim, & Morris, 2008; Scott & Jackson, 1996) and well-maintenance of the spaces and features (Rung, Mowen, Broyles, & Gustat, 2011), also determine whether or not people use a green area for PA purposes. The way the individual perceive a natural environment is also an important influencing factor. Self-perceived distance or accessibility have been found not to always match with objective measurements, and it was more strongly associated with people's visitation of natural environments (McGinn, Evenson, Herring, & Huston, 2007). Similarly, the perceived quality of urban parks has been found to be associated with resident's PA levels (Bai, Stanis, Kaczynski, & Besenyi, 2013). Self-efficacy has also been proposed as an individual factor that may limit visitation of green areas and their use for PA purposed (Scott & Jackson, 1996). Last, but not least, it has been suggested that individual dispositions towards PA or outdoor activities are likely to influence one's will to visit natural environments (A. C. K. Lee & Maheswaran, 2011). Anyway, it has also been pointed out that there is a lack of studies in this direction (Bowler, Buyung-Ali, Knight, & Pullin, 2010; A. C. K. Lee & Maheswaran, 2011).

3 Revitalization: Psychosomatic factors

3.1 Stress, stress regulation and chronic stress

The stress response is a general mobilization of the organism in order to face a situation perceived as demanding or threatening to the individual well-being. Such a mobilization leads to depletion of psychophysiological resources (Kaplan, 1995). *Allostasis* is the central process that maintains homeostasis in mammals' organism, when threatened by various forms of stress. It includes a set reactions mediated by neuroendocrine stimuli that activate and trigger immune factors and autonomic nervous system mediators (Juster, McEwen, & Lupien, 2010). The major regulators of the stress response are the Hypothalamic-Pituitary-Adrenocortical axis (HPA-axis) and the Sympathetic-Adrenal-Medullary axis (SAM), which superintend the secretions of glucocorticoid hormones (so-called 'stress-hormones', e.g. cortisol) and lead to a discharge of the sympathetic nervous system. Cumulative stress leads to an increased allostatic load, wearing out the organism from excessive exposure to stress hormones and pro-inflammatory cytokines. Such a situation is often associated to depletion of immune functions, disruption of the sympathetic/parasympathetic balance regulating cardiovascular functions and negative mental states, which on turn can lead to deleterious health consequences, such as psychological disorders, chronic fatigue, impaired sleep, cardiovascular diseases and cancer (Golden, Wand, Malhotra, Kamel, & Horton, 2011).

3.2 Nature and restoration from psycho-physiological stress

According with *psycho-evolutionary* theories, the human being is not fully adapted to living within urban settlements, which occurred in relatively recent times, while he is still instinctively connected to natural environment as original ecosystem. These principle underlie that humans feel instinctively more 'comfortable' in presence of nature, while perceiving environments lacking of elements of nature as a threat generating stressor (Biophilia theory (Grinde & Patil, 2009)). Basing on such assumptions, two mayor theories have been proposed to explain psychophysiological responses to *exposure to nature*: the Ulrich's *Stress Reduction Theory* (SRT) (Ulrich et al., 1991) and the Kaplan & Kaplan's *Attention Restoration Theory* (ART) (Kaplan, 1995). According with Ulrich's SRT, psychophysiological restoration can occur by exposure to scenes that elicits feelings of mild to moderate interest, pleasantness and calmness. The theory assigns a restorative advantage to natural environments and features of nature over artificial environments (Ulrich et al., 1991). Also in the Kaplan and Kaplan's ART, the natural environment is appointed as a powerful mean that can supply all of the components involved in the restoration process (Kaplan, 1995). Experiences in natural environments may mitigate stress, aiding in the recovery of the resources involved in the stress response (Kaplan, 1995). It has been described that the landscape is 'recognized' by our ancestral brain through the *limbic system*, interacting with the ancestral memories that are essential for survival (Gelter, 2000). The limbic system, our *'emotional brain'*, is a set of brain structures that supports a variety of functions including olfaction, emotions, behaviour regulation, long-term, memory, and motivation. The limbic system is connected through the *hypothalamus*, which gathers the limbic outputs, and enters them into the regulation path of allostasis.

Several studies have shown that being in natural environments is associated with vitalization (Ryan et al.) and elicit recovery from psychophysiological stress through attention-restoration mechanisms (Aspinall, Mavros, Coyne, & Roe, 2013). Effects of exposure to nature on indictors of stress regulation, such as stress hormones and activation of the autonomic control, have been described (Gladwell et al., 2012; Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010). While several studies have based on the assumption that the effects of exposure to nature are mainly connected with visual inputs (Grinde & Patil, 2009), a research group in Japan has associated the health benefits of being in natural environments (especially forests) to substances named *phytoncides* (essential oils from trees). These Authors reported a number of evidences regarding forest environments inducing enhanced mood profiles, reduction of stress hormones and improvement of the immune resources and cardiovascular parameters (Li, 2010).

3.3 Physical activity & nature eliciting positive mental states and psychosomatic responses

Several experimental studies have investigated psychological and physiological effects of undertaking PA in contact with nature. Experiences in natural environments, such as walking and back-packing vacations as compared to similar experiences in urban or indoor settings (Hartig et al., 1991; Ryan et al., 2010), have been shown to induce vitalizing effects and restoration from mental fatigue. Walking in forest as compared to urban settings have been also associated to improved profiles of psychophysiological markers of sympathetic nervous activity (Yamaguchi, Deguchi, & Miyazaki, 2006) and stress hormones (Park et al., 2010). In one study it was found that running outdoors in an open space with prevalence of natural elements, was associated with greater enhancements of mood profile and lower production of stress hormones, as compared to running indoors (Harte & Eifert, 1995). In this study it was also found that when the subjects were running outdoors, their mental focus of attention was directed towards 'external' elements (i.e. the environment), while when they were running indoors they had mainly an 'internal' focus of attention. A group of researchers in UK has carried out several studies on the added effects of *green exercise* (physical activities in contact with nature) on indicators of mental and physical health. In one of their earliest works, images of nature or built environment were displayed on a screen whilst the subjects exercised on a treadmill, showing that watching images of pleasant natural environment while exercising elicited improvements of mood profiles and greater reduction in blood pressure (Pretty, Peacock, Sellens, & Griffin, 2005). In other studies in the field, it was shown that green exercise experiences were associated with greater positive mental states, both in healthy (Barton & Pretty, 2010; Pretty et al., 2007) and clinical population (Brown, Barton, Pretty, & Gladwell, 2012).

4 Further health benefits of physical activity outdoors: benefits of exposure to sunlight

4.1 'Overexposure' to indoor living and 'light pollution'

A brief Introduction to biological rhythms - A person's physiological functions change periodically over time such as the day and year. These changes are known as *biological rhythms*. Human health, both physical and mental, is tightly linked to a well synchronization of the biological rhythms and the way they are tuned with the external environment. Among the different spectrums, circadian rhythms play a central role for the organism well-functioning, and *entrainment* (the synchronization of the circadian system within the 24-hours cycle) is on turn vital for a healthy functioning of the organism. In humans, the intrinsic period of a circadian rhythm is slightly longer than an exact 24-hours (Van Reeth et al., 1994); therefore it can happen that somehow in a person who is exposed to irregular environmental or behavioural conditions might experience a disruption within the circadian system. The regulation of the biological rhythm is a complex mechanism that involves peripheral, central and environmental factors. These phenomena are induced by signals from internal molecular mechanisms (so-called *clock genes*) located in central and peripheral tissues, which are superintended by internal regulators. In mammals, the main internal regulator of circadian rhythms is the suprachiasmatic nucleus (SCN), which superintends the majority of the physiological functions. The biological rhythm are also regulated by environmental signals (*synchronizers* or *zeitgebers*), which determine a precise synchronization within a certain period, e.g., 24 hours, one month, one year, and so forth. The exposure to the environmental photoperiod (day-light periodicity) seems to be the most important external synchronizer for many livings beings (Sothern, Cornelissen, Yamamoto, Takumi, & Halberg, 2009). Even if the sunlight exposure is fundamental for entrainment, several non-photic synchronizers, e.g. sleep-wake routines (Burgess & Eastman, 2006), still contribute to modulation of the circadian system. Anyway their potency compared with the sunlight yet need to be defined.

The 'sleep issue' - The wake state is strongly dependent on the pattern of the rest-activity cycle and the quality and duration of the sleep. Restricting sleep below an individual's optimal time in bed (TIB) can cause a range of neurobehavioral deficits, including lapses of attention, slowed working memory, reduced cognitive throughput, depressed mood, and perseveration of thought. Sleep loss is also known to induce deleterious effects on health, including reduced glucose tolerance, increased blood pressure, increased inflammatory markers in healthy adults, CVDs, different types of cancer and mortality. Therefore, adequate sleep duration (7-8 hours per night) is vital (Banks & Dinges, 2007). Healthy adults' sleep-wake cycle normally has a monophasic structure with one long period of nocturnal sleep. In humans, the sleep-wake cycle is generated by a circadian process, which originates from the SCN nuclei in interaction with a separate oscillatory process. These internal circadian rhythms, such as the pineal melatonin rhythm, the circadian sleep-wake propensity rhythm, and the rhythm of responsiveness of the circadian pacemaker to light, represent the so-called *sleep homeostat* (Dijk & Lockley, 2002). On the other hand, the sleep-wake cycle is also regulated by external cues; especially it is normally timed to occur at a specific phase relative to the external cycle of light-dark exposure. Alterations in these internal and external phase relationships, such as those that occur in blindness, aging, and advanced and delayed sleep-phase habits, lead to sleep disruptions and complaints. Recent findings on the physiological and molecular-genetic correlates of circadian sleep disorders suggest that the timing of the sleep-wake cycle and circadian rhythms is closely integrated but is, in part, regulated differentially (Dijk & Lockley, 2002).

The 'melatonin issue' - Melatonin (MLT) is a hormone produced by the pituitary gland. MLT in humans is mainly produced at night, but darkness is needed: light intensity greater than about 50 lux can inhibit in somehow the MLT secretion and light brighter than 2000 lux can completely suppress it. In humans, the secretion timing is modulated by the SCN through a multi-synaptic pathway. Evaluation of the serum MLT concentration is one of the most reliable indicators of *circadian phase* (like to say the 'hands' of the internal clock) (Sack, 2009). MLT has a unique position among the secretory products of the diffuse neuro-endocrine system. In humans it is associated with physiology and behaviours that are appropriate for sleep, and has an impact on other endocrine activity and organism's functions, such as insulin secretion and cardiovascular regulation (Sack, 2009). Furthermore, MLT has a wide spectrum of biological activities: the circadian organization of physiological functions, the stabilization and strengthening the coupling of circadian rhythms and, particularly, its main characteristic as a regulator of biological rhythms points to MLT as an important regulator for the coordination of intercellular interactions. Anyway, over its role within the regulation of circadian regulation, MLT as an important anti-inflammatory function: it acts on the immune system by regulating cytokine production of immune-competent cells. As a consequence, melatonin improves the clinical course of illnesses which have an inflammatory etiology. Moreover, it has an antioxidant action, scavenging free radicals, stimulating antioxidant enzymes, enhancing the activities of other antioxidants or protecting other antioxidant enzymes from oxidative damage. Several studies suggest that melatonin is a neuro-protective molecule in neurodegenerative disorders where brain oxidative damage has been implicated as a common link (Esposito & Cuzzocrea, 2010). Reduced MLT production has been associated with coronary-vascular-diseases (CVDs), diabetes (Peschke, 2008; Ruger & Scheer, 2009), different forms of cancer (Takeda & Maemura, 2010), neurological diseases with inflammatory components including dementia, Alzheimer disease, Parkinson disease, stroke, and brain ischemia/reperfusion (Esposito & Cuzzocrea, 2010). MLT production can be affected by behavioural and environmental factors. Irregular sleep-wake routines (e.g. shift work) and 'light pollution' (exposure to light at night time) might induce disruptions of the circadian structure and suppression of MLT secretion (Kloog et al., 2011). Also, light quality during the day affects night time MLT production, as well as the human circadian pacemaker (Mirick & Davis, 2008).

4.2 Physical activity, natural daylight and synchronization of biological rhythms

Light is known to be a strong regulator of the circadian pacemaker. Exposure to bright light lamps is used as a therapy for circadian rhythm disorders such as delayed sleep-phase syndrome and non-24-h sleep wake syndrome, and being outdoors, exposed to natural daylight, is also advised among non-pharmaceutical treatments for nursing-home, work rehabilitation and cancer patients (Block et al., 2009; Martin, Marler, Harker, Josephson, & Alessi, 2007). Physical exercise, although less effective, appears also to be capable of facilitating the entrainment of the human circadian rhythm (Miyazaki, Hashimoto, Masubuchi, Honma, & Honma, 2001). Physical activity is one of the lifestyle-related factors that are crucial for the quality of sleep (Atkinson & Davenne, 2007; Youngstedt, 2005). Several studies have shown that regular exercise positively impacts the nocturnal sleep (de Castro Toledo Guimaraes, de Carvalho, Yanaguibashi, & do Prado, 2008; Sherrill, Kotchou, & Quan, 1998). In a meta-analysis by Youngstedt et al. it was found that physical activity can increase total sleep time and other objective parameters related to sleep quality, even though significant modifications in terms of sleep latency and nocturnal awakenings were not found (Youngstedt, O'Connor, & Dishman, 1997). Anyway, the effects of physical activity on the sleep might depend on the time of day at which the activity is undertaken. Some studies that have evaluated physical activity in relation to circadian rhythms suggest that exercise can induce a phase-delayed effect on nocturnal reduction of the body temperature, heart rate and activity levels (Carandente F, 2006; A. Montaruli, Roveda, Calogiuri, La Torre, & Carandente, 2009), possibly interfering with the beginning of nocturnal sleep. Important aspects to consider are also the intensity, duration and type of activity that is undertaken. In order to obtain relevant effects on the sleep quality, the activity should have duration of about one hour, with a workload that is moderately intensive to vigorous. Furthermore, aerobic exercise (e.g. cycling, running, skiing, etc.) seems to impact the sleep quality better than resistance activities (e.g. weight lifting) (Roveda et al., 2011). Physical activity has been also associated with higher levels of MLT production (Escames et al., 2012; Knight, Thompson, Raboud, & Hoffman, 2005). The effects of physical activity on MLT have been studied (Escames et al., 2012), both in terms of acute response and impact on the nocturnal production, but conflicting results have been obtained. Especially, it is has been suggested that exercising at different times of day may induce different effects on MLT. Some studies suggested that intense exercise repetitively undertaken late in the day (evening) would induce a phase delay of the circadian structure (Carandente F, 2006), although a moderate exercise seems to not lead to same effects (Angela Montaruli, Roveda, Calogiuri, La Torre, & Carandente, 2005). Nocturnal exercise, both at intensive and moderate intensity, has been found to induce a delay of the MLT rhythmic pulse (Baehr et al., 2003; Buxton, Lee, L'Hermite-Baleriaux, Turek, & Van Cauter, 2003; Monteleone, Maj, Fusco, Orazzo, & Kemali, 1990; Van Reeth et al., 1994) also in controlled dim-light conditions (Barger, Wright, Hughes, & Czeisler, 2004). Some findings indicated also that exercising early in the day (morning) would lead to a phase advance of the MLT rhythm (Miyazaki et al., 2001). In another study, wherein subjects exercised at different times of day while living in dim-light and strictly controlled conditions, Buxton et al. (2003) analysed the phase-response curve (PRC) of MLT to exercise, i.e. the different effect that exercising at different times of day can influence the circadian rhythm of the MLT production. The Authors showed that the crossover point between advance/delay of phase was approximately 12-hours after the MLT uprising onset. This means that exercising later in the day (from noon to evening) would induces a phase-advance within the MLT rhythm, while exercising earlier in the day would delay the circadian phase (Buxton et al., 2003). This findings are consistent with a cross-sectional study showing that exercising later in the day (afternoon or evening) was associated with higher overnight MLT levels compared with exercising earlier in the day, controlling also for light exposure (Knight et al., 2005). The findings of the work by Buxton et al. indicate that light and exercise have different (fairly opposite) PRC. In fact, unlikely with exercise, exposure to bright light seems to induce an advance of the MLT onset with exposure occurring earlier in the day, while a delay is induced with exposure occurring in the evening, after the MLT secretion onset. In their review work, Escames et al. address the question as to why exercise and exposure to light have different PRC (Escames et al., 2012). It could be observed that, as diurnal animals, humans are naturally supposed to be physically active during daytime, while exposed to daylight. In a real life setting, the combination of physical activity and exposure to daylight, might reciprocally maintain a healthy MLT circadian rhythm, promoting a qualitative nocturnal sleep and a stable rest-activity circadian structure.

The relationship between PA, light exposure and overnight MLT production remain therefore controversial. While being outdoors exposed to natural daylight could have positive effects on the individuals' circadian structure, the time of day one engages in PAnat could still be an important factor to take into account.

4.3 Exposure to sunlight and vitamin D

Exposure to sunlight promotes the photosynthesis of vitamin D3 in the skin through conversion of 7-dehydrocholesterol. Once formed, vitamin D3 is ejected into the extracellular space, and drawn into the dermal capillary bed by the vitamin D–binding protein (Holick, 2004). Previous metabolism in the liver, vitamin D3 is then converted to 25-hydroxyvitamin D (25-OH-D), the major circulating form and indicator of vitamin D status (Holick, 2008c).

Vitamin D is vital for the organism metabolism and well-functioning. If the body becomes extremely deficient in vitamin D, only about 10%-15% of dietary calcium and 50%-60% of dietary phosphorus are absorbed (McCurdy, Winterbottom, Mehta, & Roberts, 2010). Vitamin D is therefore essential for calcium homeostasis and bone health, and its deficiency may lead to rickets, osteoporosis (Brender, Burke, & Glass, 2005) and increased risk for fractures (Morris, Turner, & Anderson, 2012). Moreover, lately an increasing number of studies have been highlighting the importance of vitamin D in preventing and treating several chronic diseases such as CVDs, metabolic syndrome, hypertension, diabetes, myocardial infarctions, and peripheral arterial disease (Maki et al., 2009; Reis, von Muhlen, Miller, Michos, & Appel, 2009).

While vitamin D can be obtained from nutrients (especially fatty fish, cod liver oil, eggs, and fortified food such as milk and cereals), moderate exposure to sunlight remain an important source of vitamin D. There is overwhelming scientific evidence suggesting that increased exposure to sunlight, which increases vitamin D3 synthesis and a person's vitamin D status, can influence the risk for an outcome of serious diseases such as multiple sclerosis (MS) (van der Mei, Blizzard, Ponsonby, & Dwyer, 2006) and many types of cancer (Holick, 2008b).

Physical activity has also been associated with higher vitamin D levels, and exposure to sunlight has been suggested as a possible reason explaining such findings (Ohta et al., 2009). In a cohort study conducted in Japan, authors investigated the association between 25-OH-D and lifestyle factors in young Japanese women. Lifestyle factors included nutrients intake, physical activity, and duration of sunlight exposure. Physical activity was measured by accelerometry and questionnaire. Two main findings of the study were that energy expenditure for exercise (kcal/day) and daily number of steps was positively associated with 25-OH-D. Furthermore, the average amount of time per day spent in sedentary activity was negatively associated with vitamin D (Ohta et al., 2009). Contrarily to expectations, self-reported amounts of sun exposure were not found significantly correlated with vitamin D levels. Anyway, it was not assessed whether the physical activity was carried out indoors or outdoors, nor whether the participants used sun-lotions that may have screened the UVB radiations. The Authors therefore suggest that PA is a life-style factor that positively impact people's vitamin D levels.

SECTION III

THE RESEARCH PROJECT

5 The pilot study

5.1 Methods

Study design – the study was set as a semi-randomized intervention trial with parallel groups, with preliminary and baseline measurements, an intervention, and a 10-weeks follow-up (figure 1).
The subjects underwent a PA-based intervention, which consisted of three sessions (one baseline and two PA sessions) over one week-span; two and ten weeks after the intervention, the subjects were contacted again via e-mail, and asked to complete some on-line measurements.
Three standardized experimental conditions were tested:
Baseline= sedentary activity (computer test + attending a seminar/lecture) indoors.
PAind= indoor setting with no access to visual contact with nature ('traditional' exercise environment);
PAnat= outdoor setting in contact with nature (green/natural environment).

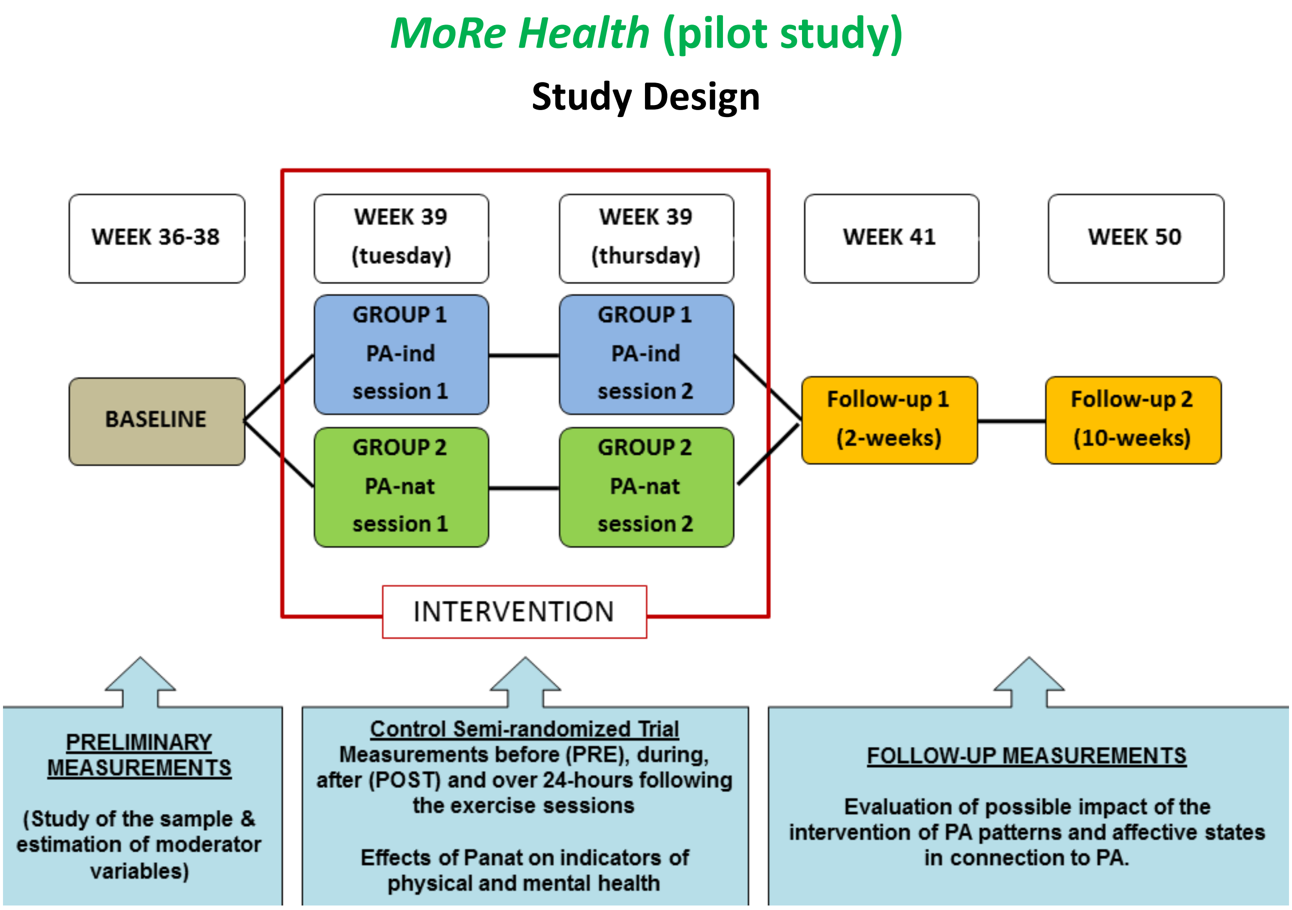


Figure 1. Schema of the study design of the pilot study funding on the 'MoRe Health' rationale

Subjects - The study sample was healthy adults, sedentary or moderately fit, in working age. The subjects were recruited among employees in two large institutions of a city in north Norway, the *Finnmark University College* (*Høgskolen i Finnmark*, HiF) and *Alta Municipality*. All the subjects were informed of the benefits and risks of participating in the research project, and signed an informed consent. The study was approved by the Norwegian Social Science Data Service (project n. 30906, approved in date July 13th 2012)

Recruitment - An invitation to participate to a seminar was sent by e-mail to all the employees of Alta Municipality and HiF. The invitation consisted in an electronic flyer (figure 2), wherein general information about the seminar and the participation terms were explained. Those who were interested in participating were invited to take contact with the research coordinator via e-mail or telephone. Within the two weeks preceding the intervention (week 36 and 37), the respondents were invited for a private interview with the project leader, who explained the details of the project and assessed the compatibility with the including criteria. Excluding criteria were: invalidating musculoskeletal impedance to the type of physical activity proposed and severe cardiovascular diseases. If the subject met the including criteria and accepted to participate in the project, she/he signed an informed consent and filled in a preliminary questionnaire. Afterward, a temporary alphanumeric ID code was assigned to each participant, and an appointment to undergo a cardiopulmonary fitness test was set.

Figure 2. Invitation to participate at the pilot study

Group assignment - Only after the preliminary investigations, the subjects who were selected for participating in the seminar-intervention were divided in two groups (PAnat- and PAind-group). Due to the small sample size, the groups were created according with a semi-random approach that aimed to maintain a balance of age, gender and physical activity levels. Males and females were listed in two separated columns, ranked for age and associated to a shorter categorization of active/sedentary (sedentary= activity levels < 2.5 hours/week). Afterwards the subjects were progressively assigned, randomly, to the PAnat- or PAind-group, distributing fairly equal number of males and females in each group. In the end, it was controlled that there was a fairly balanced distribution of active and sedentary within the two groups. Eventually, a final ID code composed by two numbers, with the first indicating the group (1= PAind and 2= PAnat) and the second was a progressive number (from 1 to 7) assigned to each subject. All the samples and any information about the subjects were recorded through this ID coding-system. The subjects were informed of what group they were going to be part only during the baseline session (Day 1).

Intervention - The intervention consisted in a seminar that aimed to provide theoretical fundaments and practical guidelines about how to plan and maintain an exercise program. The seminar was compounded of one theoretical meeting (baseline) and two workshops (interventions). The seminar/intervention took place in September, across weeks 38 and 39 (Thursday – Tuesday – Thursday). Each of these days the subjects met at the Finnmark University College at 15:00, after a regular working day. In day1 (Thursday week 38), they attended an informational seminar about benefits of physical activity and recommendations from national and international institutions. A major focus was given to the importance of embrace an active lifestyle in one's daily routines (e.g. active transport or using stairs rather than elevator). In day2 and day3 (Tuesday and Thursday, week 39) the participants were divided in two groups: one group undertook an exercise program indoors (*PAind*), while the other undertook the same type activity in a natural environment around the College (*PAnat*). After the activity, they all gathered together for dinner (17:00), and eventually went home afterwards (17.30).

The Exercise Program - The exercise program was compounded of two parts: a biking session (25-minutes), and strength session using elastic resistance rubber-bands with handlers (20-minutes). The biking session was compounded of warm-up, work-out and cool-down (5-, 15- and 5-minutes, respectively). Preliminary the biking the Borg scale (described below) was showed to them. They were asked to keep a moderate intensity during the warm-up and the cool-down parts (Borg 11-13), and a moderately high intensity during the work-out (Borg 14-16). Besides, they were instructed to pay attention on their breathing frequency, which was supposed to be sensibly faster but still allowing to breath with the nose during the warm-up and cool-down, while it was supposed to be quite hard (breath with the mouth) during the work-out. The strength part included a set of eight exercises covering all the major muscular groups: lower limbs, lower- and upper-back, shoulders/upper-limbs, shoulders/chest muscles, and abdominals. The exercise bands use for the strength part was of the type with tubular elastic and hard-plastic handlers, and they were exactly the same for both groups. Females used the medium-resistance (green band), while males used the hard-resistance (red band). The Activity sessions were led by experienced instructors. In order to avoid as much as possible influences connected to different instructing-styles, preliminarily the instructors underwent a brief training period in order to standardize the exercise protocol and plan the content of the communications. During the week of the intervention (including the 48-hours before the baseline and the activity days) the participants in the seminar were asked to avoid PA other than the one planned for the intervention. Especially, those who participated in the PAind group were asked to avoid outdoor activities such as bicycling to/from work or taking long walks. During all the sessions, the subjects had free access to water (special drinking bottles were provided as gadget from *Sykkelbyen Alta*). A light snack (fruit and a cereal bar) was served before the activity, and dinner was served for all the participants at the Cantina of the Finnmark University College after the activity.

The environmental setting - The indoor setting aimed to reproduce a 'traditional' exercise setting, as often is proposed in exercises proposal to employees (figure 3). This setting was carefully studied so that the subjects did not have direct exposure to natural daylight, visual contact with nature, or direct external air (the room was provided with a ventilation system). At the same time, the environment was not oppressive, for instance because of lack of prospective, light and colours. The room was well illuminated with artificial light, and light also filtrated through a large line of windows covered by white curtains. Multiple colours enriched the environment (yellowish walls, colourful mats and wooden complements), and a large mirror covering the wall in front of the bikes lines amplified both light and space perception in the room. The subjects used Spinning® Fitness indoor bikes, which were borrowed from *Actic Alta* fitness-centre. For the PAnat, a track was selected in a green area that surrounded the College (figure 3). The subjects biked on a patch surrounded by relatively small trees. The rubber-bands session was undertaken on a green space behind the College, which was surrounded by high bushes and faced the forest. The subjects had the option to use bikes provided for the project by the *Sykkelbyen* Municipality of Alta. Anyway, in preliminary trials we found that when biking outdoors the experience can be significantly affected from the perceived quality of the bike, therefore the subjects were allowed to use their own bike, if they wished so.

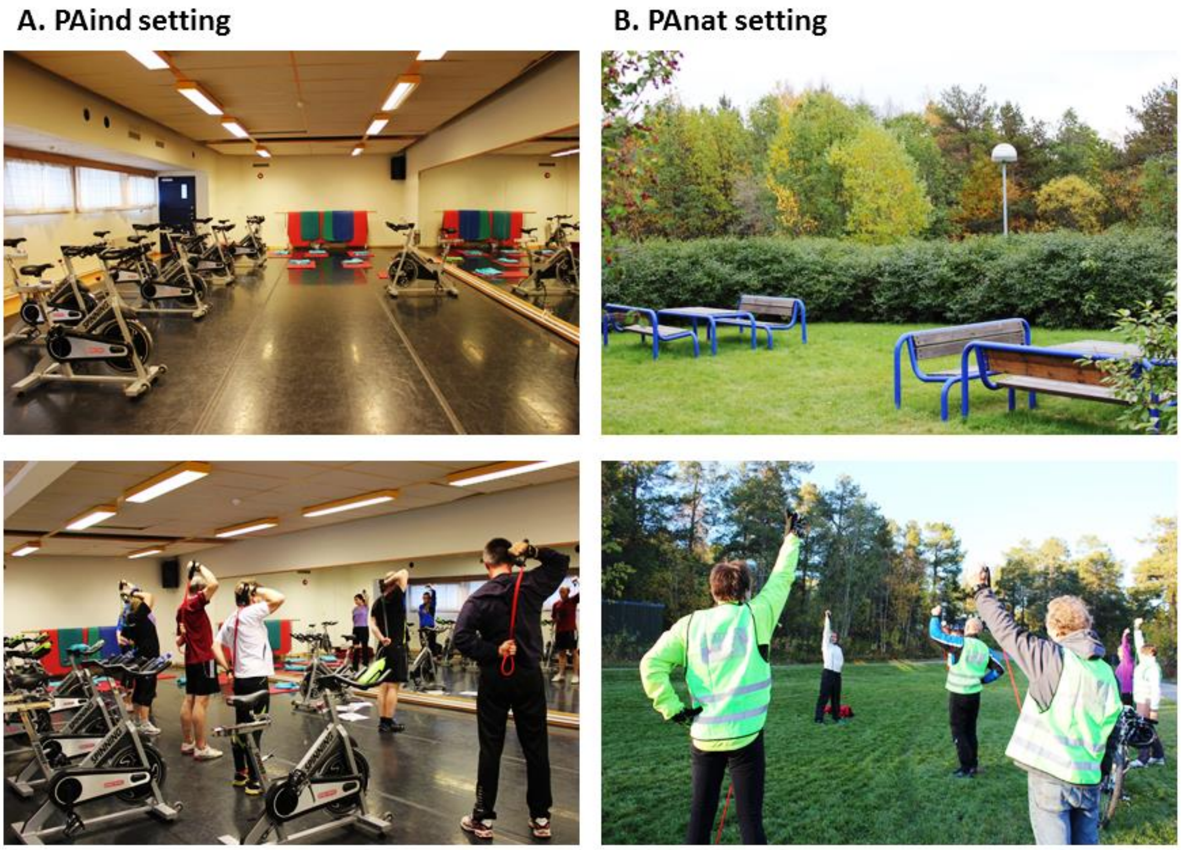


Figure 3. Environmental settings (i.e. experimental conditions)

Assessment of the exercise program in the different environmental settings - Besides environmental factors, undertaking physical activities such as biking in indoors rather than outdoors settings is intrinsically different, because of different muscular intervention and balance challenges. Therefore, before the intervention took place, the exercise program was accurately planned and preliminarily tested in order to make the physical workload as similar as possible across the two environmental conditions. In this way, we aimed to avoid confounding effects due to the physical exertion, while better studying possible effects due to environmental factors. Yet, environmental qualities of the exercise settings and the physical exertion (both, actual and perceived) were measured during the intervention, in order to use this data as control variables. In these preliminary investigation (assessment study), a smaller sample of younger and fit subjects who have good experience with physical activity (N= 5, 4 females, age 29-39; BMI 24.0±1.05, $V{\cdot}O_{2max}$ 48.3±3.17 ml/kg/min), undertook a shorter program (about 20-minutes biking) in both the environmental settings. Preliminary, the subjects underwent a maximal incremental cardiopulmonary test, in order to determine the individual's exercise zones with high precision. The PA task consisted in a 5-km biking on the same track that was planned to be used for the interventions on employees. They were provided with a HR-monitor watch (Polar RS400, Polar Electro, Kempele, Finland) and instructed to bike at an intensity corresponding to the 70% of their individual VO2max. HR, time of completion, Ratings of Perceived Exertion (RPE, Borg scale) and enjoyment were measured during the exercise session. At the completion of the exercise session, they filled in the 7-items scale for restorative qualities of the environment. All the subjects undertake a biking session in the outdoor setting first (day1), and the following day (day2) the HR profile and the time of completion recorded during the outdoor session was reproduced during the biking session indoors. HR, RPE, enjoyment and perceived restorative qualities of the environment were measured also in connection with the indoor session. Furthermore, the subjects were also asked to report environmental preferences and free-thoughts in connection with the experiences in the outdoor/indoor settings.

Measurements and instruments

The protocol included a number of measurements of psychological (questionnaire) and physiological (biological samples and measurements of physical values), which were organized on different time-steps:

- Preliminary measurements: were performed before the intervention took place and aimed to provide background information of the sample and to be used as moderators in the final data analysis. :
- Measurements within the intervention were performed during the sessions in day1 (baseline), day2 and day3, and aimed to 1) control perceptual and effective factors in connection with the environment and the physical activity and 2) estimate psychological and physiological responses to the exercise. These measurements were collected in different time-points:
    - PRE measurements (performed immediately before the session)
    - DURING the exercise sessions
    - POST measurements (performed immediately after the session)
    - Medium/long term measurements (performed within the 24-hours following the intervention)
- Follow-up: were performed two and ten weeks after the intervention (FU-1 and FU-2, respectively). These measurements aimed to investigate possible long term effects of the intervention in the subjects.

Preliminary measurements (background)

Protocol - The preliminary measurements aimed to provide background knowledge for what concerns the subjects' health and the PA status. During the individual preliminary interview with the research responsible, the subjects filled in a questionnaire containing four sections: 1) general demographical, occupational, and health information; 2) Connectedness to Nature Scale; 3) Mood, measure by Physical Activity Affective Scale; and 4) an adjusted version of the Godin's Leisure Time Exercise Questionnaire. They were also asked to describe with their own words how active they were, what type of physical activity they are used or liked to do, and what is their relationship with exercise. This allowed a better interpretation of the Exercise Questionnaire, in order to obtain more precise outputs. Following the preliminary interview with the researcher, the subject underwent a fitness test for the determination of the individual HR maximum (HR_{max}) and maximum oxygen up-take ($V{\cdot}O_{2max}$). Eventually, before the baseline session, the subjects performed an *Implicit Association Task* (IAT) for the determination of their implicit attitude towards PA.

- **Demographical, occupational, and health information –** This section was a 1-page table with close-answer options, wherein the subjects were asked to provide demographical and anthropometrical (gender, age, body weight, high), socio-cultural (familiar status and education degree), occupation (position and occupation percentage), and relevant health information (presence of severe health problems limiting PA and use of drugs/medicines).
- **Connectedness to Nature Scale (CNS) (Mayer & Frantz, 2004) –** CNS is an instrument measuring to what extent one feels connected to nature. CNS is 15-items scale consisting of statements to which the subject has to indicate degree of agreement, ranging from 1= strongly disagree to 5= strongly agree.
- **Physical Activity Affective Scale (PA**AS) (Lox, Jackson, Tuholski, Wasley, & Treasure, 2000) – PAAS is an instrument measuring exercise-induced affective states, both as 'acute' affective response to exercise and mood (more stable expression of the affective state). The instrument is based on the *circumplex model of affect* and arousal (Russell & Mehrabian, 1974), in which two bipolar axes, reflecting 'positive-negative' and 'high-low' activations, are situated orthogonally to each other. It would therefore place feeling states in connection with exercise within four factors, which correspond to the quadrants of the circumplex model: 'Positive Affect' (positive-high activation), 'Tranquillity' (positive-low activation), 'Negative Affect' (negative-high activation), and 'Fatigue' (negative-low activation). PAAS consists of 12 items, consisting of affective states such as "exhausted", "relaxed", "optimistic", and "enthusiastic" measured on a 5-point Likert scale (0= strongly disagree; 1= disagree; 2= neither agree nor disagree; 3= agree; 4= strongly agree). At this stage of the study, the subjects were addressed to refer to their feeling state in that broader period (in the caption: "describe how you feel generally in these days").
- **Godin's Leisure Time Exercise Questionnaire (LTEQ) (Godin & Shephard, 1985) –** the Godin's LTEQ is an instrument that aims to estimate the frequency and intensity one's engage in physical activity within a typical week, during their leisure time. The strength of this instrument consists in distinguish in different levels of intensity associated to different types of physical activity (*intensive*= high pulse; *moderate*= slightly exhausting; *light*= minimal effort). For each intensity level, examples of physical activities are also provided in order to make it more understandable for the subjects. This questionnaire was adjusted according to the rationale of the study and the characteristics of the population. First, in the caption we included "*active transport*" as a possible source of physical activity, while this was a lack of the original version. Also, the minimum duration to be considered was extended to 30-minutes, which could have been compounded of two sessions of 15-minutes within the same

day, in order to be coherent with recommendations from the Norwegian health-institution. Secondly, in the original version of the LTEQ, for each intensity level the subject is required to express the *frequency* ("how many times in a week") one engage in that type of physical activity. In our version, in addition the subject were asked to report the overall time he engage in physical activities at that intensity level over a typical week. Finally, in a separate section, the original LTEQ, the subject is asked to indicate "how often" (*often, sometimes, seldom/never*) one engages in any physical activity intensive enough to "make a sweat"; in our version we wished to 'lower' the reference to any physical activity intensity enough "to get warm". In addition to the LTEQ, and section concerning the environmental preferences when exercising were included. The caption was *"Generally speaking, when you undertake any physical activity, where does it take place for the most"*. Following, different options were listed, divided in two categories: indoors (at home, in a training-centre or other infrastructure equipped for exercise, in a swimming-pool, other) and outdoors (in your garden, in your neighbourhood or the city-streets, in a park or urban green space, out in nature such as a forest or open mountain, other). The subject was asked to select up to three options, rating his preference (1= most commonly).

- **Fitness test –** The test was performed on a cycle-ergometer (Lode) and consisted in a 4-incremental-steps + an incremental-ramp up to maximal exhaustion. The test protocol was set as follow: 5-minutes warm-up at 25W; the next intensity level was set basing on the HR values at the end of the warm-up (HR < 80 bpm → 125W; HR= 80-89 bpm → 100W; HR= 90-100 bpm → 75W; HR > 100 → 50W), followed by three steps, 3-minutes each, with a 25W increase; at the end of the step-test, the intensity increased 10W every 20-seconds, up to complete exhaustion. During the test, HR, ventilation rate, and respiratory gasses (oxygen and carbon dioxide), were measured using the Oxycon Pro ® by Jaeger system. During the test, the subjects had visual access to time and test's outputs, and they also received motivational encouragements from the lab-assistants. HR_{max} was determined as *HR peak during the test + 5*. $V{\cdot}O_{2max}$ was determined as the mean of the three highest neighbour values, adjusted for the subject's bodyweight (ml/kg/min) during the test; furthermore, the absolute values were adjusted for and categorized for gender and age according to the Norwegian Health Ministry guidelines (Helsedirektoratet, 2010): 1= 'very low'; 2= 'low'; 3= 'middle/average'; 4= 'high'; 5= 'very high'; 6= 'top level'. Following the test, a scheme containing a graph and a table with different percentages of HR_{max} and $V{\cdot}O_{2max}$, and the corresponding exercise workload, was produced in order to determine the subject's workload when undertaking the exercise sessions. As part of the seminar/intervention, the subjects received copies and personalized explanation concerning the test's outputs, how to interpret the results, and how to use them to plan their exercise in future.
- **Implicit Attitude Towards Physical Activity (IATPA) (Greenwald, McGhee, & Schwartz, 1998) –** Before the baseline session, the subjects were gathered in a computer-room at HiF, and performed an Implicit Association Task (IAT) for the determination of the individuals' implicit attitude towards PA. The IAT is a latency based measure of the relative associations between a target concept (physical activity/sedentary) and an attribute concept (good/bad). In a series of tasks, participants sort words representing a physical (in)activity (e.g. running or sitting) and words with positive/negative valence, such as 'good'/'bad', into two categories (indicated by right or left location on a computer screen). The physical activity category is paired with both positive and negative stimuli in different stages of the test. Faster categorization of physical activity words when paired with 'good' indicates a positive attitude toward PA. The stimuli words were chosen based on a pre-test. The chosen target words scored unambiguously on the level-of-physical-activity dimension, but were neutral on the

valence dimension, and the chosen attribute words scored unambiguously on the valence dimension, but were neutral on the level-of-activity dimension. Finally, the stimulus words were matched on the basis of visual similarity as determined by word length and first letter.

- **Rest-activity rhythm –** *Actigraphy* – During the course of the intervention, a 1-week long continuous monitoring by Actigraphy device (Act sleep+, Actigraph™, Pensacola, US) was performed. The Actigraph+ is a device in size and shape similar to a wrist-watch that contains a 3-axial accelerometer and a light sensor, which allow to measure and record individual's movements and light exposure in continuous monitoring. The participants wore the actigraph on their right wrist continuously during the overall duration of the seminar, starting day-1 (baseline), and finishing the morning after the second activity session. Therefore, the Actigraphy monitoring covered three regular working days, 'free-schedule' days (week-end), and the days the PA sessions took place. The Actigraphy data were downloaded and analysed using the Actilife-6 software. The data were treated first by the 'Wear Time Validation' feature, and then processed using the 'Data Scoring' and the 'Sleep Analysis'. From the analyses of actigraphy data a number of parameters of PA (e.g. Average kcal consumption, METs and Step counts) and sleep patterns (e.g. total sleep time, sleep efficiency, number of nocturnal awakenings) can be obtained.

Measurements within the intervention

Protocol - In day-1, before the Baseline session started, the participants wore an Actigraph device on their right wrist, and were instructed to wear it continuously for one entire week. They also received a sleep diary, which they were asked to fill in every day. Furthermore, in the day-1, -2 and -3 of the intervention, all the subjects met at HiF at 15:00, after their regular working day. They wore the HR-monitor belt, took a saliva sample and complete the PAAS (PRE). Afterward, they received a snack and water, and undertook the activity set for the day (i.e. sedentary activity indoors or PAind or PAnat). In day-2 and -3, they filled in a short questionnaire (RPE, enjoyment, PAAS, intention to exercise in future, and perceived *Fascination* and *Being Away*) during and after (POST) the exercise sessions. At the end of the activity, (16:30) the subjects took another saliva sample and went to the cantina at HiF, where dinner was served to them. Before beginning eating, they took another saliva test. After dinner, before going home, the subjects received a thermic bag containing an ice element, equipment and instructions for the home-made monitoring (four *salivettes* for saliva sampling and a plastic tank for the urine collection). The subjects were instructed to empty the bladder in the toilette at 18.00, and beginning from that moment the urine collection, and take another saliva sample at 21:00. The following morning, they took three saliva samples at awakening, +15-minutes, +30-minutes. They were instructed to keep all the samples (saliva and urine) in the thermic bag, which they took with them to work. Two stations were set, one at HiF and one at Alta City Hall: between 8:00 and 9:00, according to a pre-fixed schedule, the subjects met the researchers in the station that was more convenient for them to reach, they concluded the urine collection, delivered the thermic bag with the biological sample, the HR-monitor belt, and took a BP measurement and a blood test. Eventually they could continue their regular working day. The morning following day-3, the subjects delivered the Actigraph device and the sleep diary to the researchers.

Psychological and physiological responses to the exercise

- **Affective response –** the affective response was measured using the PAAS (Lox et al., 2000) (see above) in its 'acute' form (in the caption: "describe how you feel at this moment in time"). The scale was completed before (PRE) and after (POST) each exercise session.
- **Enjoyment -** Rating of Enjoyment were recorded immediately after the biking and the rubber-bands sessions. The Enjoyment scale consisted of a single-item, which asked "on a scale from

0 to 10, how enjoyable is the activity you have been undertaking?" The subjects reported their answer on a numbered line underlying the item.

- **Restorative Qualities of the environment** – Restorative qualities of the environments were determined through a 7-items scale of *Fascination* (five items) and *Being Away* (two items), in accordance with Kaplan & Kaplan's ART and previous works on restorative effects of recreational activities in contact with nature (Hartig et al., 1991). The scale was submitted after the exercise sessions, while the subjects were still in the exercise-environment. The subjects were required to assign a score to each of the seven items/sentences, according to their degree of agreement/disagreement. The rating scale, which ranged from zero to ten, was displayed on a numbered line above the items, with three short descriptions at zero (absolutely disagree), five (neither agree nor disagree) and ten (absolutely agree). A caption instructed to refer to the environment the subject undertake the activity session.
- **Intention to exercise in future –** The subjects' Intention to exercise in future (defined as the following 10 weeks) was measured by a scale compounded of three items, on a scale from -3 to +3 (-3= strongly disagree, 0= neither agree nor disagree, +3= strongly agree). A headline caption explained how to fill in the scale. The subjects received a definition of 'exercise' at the beginning of the seminar/intervention.

Physical exertion and perceived environmental qualities during the exercise sessions

- **Temperature and light-exposure –** the temperature and humidity levels of the indoor setting was measured by thermometer-hygrometer. The temperature and humidity for the outdoor setting was determination through internet weather report. The light exposure during the intervention was measured by a light sensor included in the Actigraph device (see below). In order to study the participants' light exposure, a lux analysis was performed ('Data Scoring' function), setting a filter for a time-window 6:00-18:00. The outputs were exported on an excel file in a daily/hourly breakdown, which allowed to proceed with further calculations of light exposure during the seminar sessions (Thursday-Tuesday-Thursday, time-window 15:00-17:00). The outputs of the participants' daily light exposure over the overall monitoring are reported in figure 1.
- **Heart rate (HR) –** subjects' HR was used as effective measures of workload. It was measured by HR monitor, using the Polar-Team2® system (Polar Electro, Kepmele, Finland). The subjects wore only the monitor belt, with no watch; therefore they had no visual access to their HR values during the exercise session. After the exercise sessions, the HR data were downloaded on a PC through the Polar-Team2® software, and exported as excel files. Averages were calculated in different time-spans:
    - **PRE-exercise values** (10-minutes), with the subjects laying quietly in a semi-supine position, five minutes served for stabilization of the HR values and the following five minutes were the actual measurement;
    - **Biking bout** (25-minutes), that is the time span between the beginning and the end of the biking session;
    - **Strength bout** (20-minutes), that is the time spam between the beginning and the end of the exercise program with the elastic rubber bands;
    - **POST-exercise recovery** (15-minutes), which included three five-minute bouts, including 5-minutes while the subjects were filling in the questionnaire, and ten minutes with the subjects lying quietly in a semi-supine position (5-minutes for stabilization and 5-minute of actual resting condition).
- **Ratings of Perceived Exertion (RPE)–** RPE was measured by Borg 20-items scale (Borg, 1982). This scale displays a column of numbers ranging from six (rest) to 20 (maximal

exertion); some of the numbers are associated to brief descriptions, corresponding to seven intermediate intensity levels (7= extremely light; 9= very light; 11= fairly light; 13=somehow hard; 15= hard; 17= very hard; 19= extremely hard). This measurement was taken in three different time-points: during the biking session, while they were still pedalling (end of the 'work-out'), and immediately after the biking and the rubber-bands sessions. At the first time-point ('during biking') the scale was showed on a panel, and the subject was asked to point with the finger (to avoid possible influences on other participants) what degree of exertion he/she perceived in that very moment. For the other two time-points, each subject received a paper displaying the RPE scale that they had to cross in correspondence of the perceived exertion recalled from the corresponding activity.

Markers of autonomic control

- **Heart Rate Variability (HRV) –** HRV is parameter of interest in psycho-physiology and also a marker of autonomic control strongly connected with health risk such as cardiac mortality. Therefore, beat-to-beat data was recorded overnight with a HR monitor belt (Polar Team2 system, Polar Electro®, Kempele, Finland) for further HRV analysis. Recommendations of Brandenberger et al. (2005) were followed in order to isolate 5-minute sequence during the first slow wave sleep for the further HRV analysis (Brandenberger, Buchheit, Ehrhart, Simon, & Piquard, 2005). The first low wave sleep period was recognized after two criteria: 1) the first or the second 5 min period of the first low and regular HR episode lasting at least 15 min, and 2) a round Pointcaré plot. Also, the lowest SD of the heart rate in the period of interest (Al Haddad, Laursen, Ahmaidi, & Buchheit, 2009) if a further criterion was needed. This period was also automatically interpolated as well as manually inspected for artefacts and ectopic beats by using heart rate recorder compatible software (Polar Team2 system, Polar Electro®, Kempele, Finland). HRV data for frequency analyses, which study the spectral components of the tachogram, were processed by HRV analyse software (Kubios HRV, Biosignal Analysis and Medical Imaging Group, Kuopio, Finland). The power was calculated with The Fourier Transform algorithms from the beat-to-beat periods in various lengths that represent the parasympathetic and sympathetic modulation of the heart.
  The parameters of HRV that have been considered for this study are:
  - **HF n.u.** : high frequency power (estimate of the parasympathetic activity) in normalized units, HF [ms2]/(total power [ms2] − VLF [ms2])
  - **LF n.u. :** low frequency power (estimate of the sympathetic activity) in normalized units, LF [ms2]/(total power [ms2] − VLF [ms2])
  - **LF/HF:** Ratio between LF and HF band powers, Reflects the sympatho-vagal balance controlling the heart rate, an index of sympathetic activation
  - **Mean RR:** interval oscillation between two adjacent R waves.
  - **SDNN**: standard deviation of RR intervals
- **Blood Pressure (BP) –** BPs were measured the morning (between 8:00 and 9:00 AM) following the sessions in day1 (baseline), day2 and day3. The subjects met the researcher in two meeting- points situated at HiF and the Alta City Hall, so that they were in their work environment at a regular time, when they took the measurement. BP was measured by automatic sphygmomanometer (MW701, Rossmax Medical®, Berneck, Switzerland), after the subject was sitting quietly on a chair for five-minutes. Two measurements were performed (a third measurements was made only in case there was a difference >10mmHg between the measurements), at one minute apart; the values were averaged for the final output.

Cortisol as marker of the Hypothalamus-Pituitary-Adrenocortical axis activity

- **Circadian profile of the salivary cortisol expression** – Saliva samples were collected by chewing a cotton swab (Salivette, Sarstedt, Numbrecht, Germany) in 7 time-points: 15:00 (pre-exercise), 16:30 (post-exercise), 17:30 (30-min post-exercise), 21:00, and three within 30-minutes after awakening the following morning (awakening, + 15-min, + 30-min). No salivary sample was analysed fresh; all samples were subjected to a single freeze–thaw cycle and on the day of the assay they were centrifuged at 1000g for 15 min, so as to break down and remove the mucopolysaccharides that could interfere with accurate pipetting. The saliva samples were analysed by electrochemiluminescence immunoassay (ECLIA), using the Roche E 170 module (Roche, Basel, Switzerland).
  From the circadian profile of the cortisol production (measure of the salivary concentration, figure 12) we obtained and studied different parameters:
  - **PRE-POST exercise** values (increment%), compared to 15:00-16:30 production at BASELINE;
  - **POST-exercise recovery** (slope within the 30-minutes after completion of the exercise session);
  - **Diurnal slope** (calculated on the time-points from 15:00 to 21:00);
  - **Amplitude of the rhythm** (difference between the highest value measured in the morning and the lowest value measured between 17:00 and 21:00);
  - **Awakening response increment** (slope within the 30-minutes from awakening).
- **Overnight cortisol (CORT) production in urine** – The urine collection began at 18:00 (after emptying the bladder) and was concluded at 8:00 AM the following morning. All the urine produced within this time window was collected in plastic tanks. The overnight urine CORT production was measured in double samples through determination of free CORT in urine by Solid phase competitive luminoimmunoassay (LIA) using the Immulite 2000 kit (Siemens Healthcare Diagnostics, Munich, Germany).
- **Early morning serum cortisol** – Blood was drawn through injection by professional nurses. Serum cortisol was determined in double samples by Solid phase competitive luminoimmunoassay (LIA). Immulite 2000 kit (Siemens Healthcare Diagnostics, Munich, Germany) was used.

Biological Rhythms and Sleep-wake patterns

- **Sleep patterns –** Sleep patterns were assessed by crossing the Actigraphy data with the data reported in the sleep diary. From the Sleep Analysis performed by the *Actilife* software, parameters describing the quality of sleep were calculated: Time in Bed (TIB), Sleep Efficiency (SE%), Total Sleep Time (TST), Sleep Latency (SOL), Wake After Sleep Onset (WASO), number of Nocturnal Awakenings longer than 5-minutes (NA>5), and Total Activity Score (TAS). In the sleep diary, the subjects reported the ‘in bed’ and ‘out of bed’ times, their perceived sleepiness at bed-time and awakening, their perceived quality of sleep, and the perceived sleep latency and how easily they got up. The sleep diary was set as a table that included eight columns: 1) date, 2) bedtime, 3) perceived sleepiness when going to bed (rated on a scale from 0= not sleepy at all to 10=very sleepy), 4) wake-up time; 5) total sleep quality (rated on a scale from 0= could not sleep to 10= very good), 6) latency of sleep (“how quickly did you get asleep?”: A= immediately, B= a few minutes, C= quite a long time), 7) gap between first awakening and getting up (“did you get up…”: A= before/without the alarm, B= when the alarm rang, C= after the alarm, e.g. did not hear it or set the snooze-mode), 8) sleepiness at wake time (rated on a scale from 0= not sleepy at all to 10= very sleepy). The subjects were instructed to keep the diary beside their bed, so that they could fill it every day: the first three columns at bed-time, and the others at soon as awakening. There was also a section wherein the participants could record when undertaking PA, taking naps, taking the monitor off and putting it back on or communicate any other information to the researchers concerning the monitoring. From the actigraphy and the sleep diary, the following parameters are defined:

- **Bed Time**: time in bed
- **Out Bed Time**: get up time
- **Sleep Latency Onset (SOL)**: span between Bet Time and the actual beginning of the sleep
- **Time in Bed (TIB)**: Span between Bed Time and Out of Bed Time
- **Total Sleep Time (TST)**: Total time (minutes) of actual sleep within TIB
- **Sleep efficiency (SE%)**: Percentage of actual sleep within TIB
- **Wake After Sleep Onset (WASO) adjusted per TST (%)**:Total amount of time (minutes) of time awake after the sleep onset (WASO) adjusted as a percentage of total sleep after sleep onset
- **Average Counts in TIB**: Activity (counts) recorded within TIB
- **Sleepiness at Bed Time (SBT)**: Self-reported ratings of sleepiness at Bet Time
- **Perceived Sleep Quality (PSQ)**: Self-reported quality of sleep
- **Perceived Sleep Latency Onset (PSOL)**: Self-reported duration of the sleep latency time
- **Perceived Sleep Offset Latency (PSOffL)**: Self-reported duration of lying in bed awake before getting up
- **Sleepiness at Wake-up Time (SBT)**: Self-reported ratings of sleepiness at get-up time

Overnight melatonin (MLT) production – overnight MLT production was estimated through determination of 6-sulfatoxymelatonin in urine, through Enzyme immunoassay using DRG Melatonin-Sulphate EIA-1432 kit (DRG International Inc., Springfield, USA). The method's principle is that An unknown amount of antigen present in the sample and a fixed amount of enzyme labelled antigen compete for the binding sites of the antibodies coated onto the wells. After incubation the wells are washed to stop the competition reaction. After the substrate reaction the intensity of the developed colour is inversely proportional to the amount of the antigen in the sample. Results of samples can be determined directly using the standard curve.

Vitamin D

- **25-OH-VitD3 in serum -** The serum levels of Vitamin D were determined through a self-developed method applied at the Hormone Laboratory since September 2012. The method consists in a liquid chromatography-tandem mass spectrometry (LC-MS/MS), which determine the separation of 25-OH-Vit D2 and 25-OH-Vit D3 and possible interferences of reversed phase LC detection with electrospray-MS/MS (MRM). The method determines the serum concentrations of both 25-OH Vit. D2 and 25-OH-vit. D3. In this connection it is important to remember that vitamin D2 is not produced in the human body. This means that 25-OH-Vit. D2 only found in people who use vitamin D2-containing medications (such as AFI-D2 forte).

Follow-up

Protocol - The follow-up aimed to investigate possible changes in the subjects' PA levels in connection with their IATPA and affective state after participating in the intervention. Two and 10 weeks after the intervention, on Monday afternoon (around 15:00) an e-mail was sent to all the participants, asking them to complete on-line a follow-up questionnaire and an IAT. The subjects could access both the questionnaire and the IAT through two links attached in the e-mail. After three days, the response rate was controlled, and a reminding e-mail was sent to those who had not responded yet. A second reminder was sent if response did not occur after five days. Then, both the links were closed within one week from the day the e-mail was sent (Monday morning).

- **Follow-up questionnaire –** The follow-up questionnaire was designed through *QuestBack* system (http://www.questback.no) and included a PAAS scale, in its 'mood' version (in the caption: "describe how you feel generally in these days") and a shorter version of the GLTEQ. The latter inquired for the amount and frequency the subjects engaged in PA (with reference time the previous two weeks). At this stage of the study, the PA was not classified in 'intensive', 'moderate' and 'light', but the subjects were only asked to provide a total amount of hours he/she was engaged in PA, including active transport ('less than 1-hrs/week', '1-2 hrs/week', '3-4 hrs/week', spent in PA, '5-6 hrs/week', or 'more than 7-hrs/week'). They were also asked do indicate the frequency they engage in PA "long enough to increase the body-heat (increased heart beats)", and how often the biked indoors and outdoors in nature, and how often the exercised using the elastic rubber bands as learned during the seminar. Accordingly with GLTE pattern (item-2), the frequency was expressed as 'OFTEN', 'SOME TIMES', or 'SELDOM/NEVER'. Eventually, they were inquired about their environmental preference for exercising by assigning a mark of frequency ('seldom/never', 'some times', 'often', or 'most of the times') to a list of exercise settings (see GLTEQ in 'Preliminary measurements').
- **Implicit attitude towards physical activity (IAT) (Greenwald et al., 1998) –** The IAT was set identical to the version that was administered in the preliminary measurements (see above).

5.3 Outputs and Preliminary Results

Part of the preliminary findings have been presented at the 18th Annual Conference of the European College of Sport Science (ECSS, Barcelona, 25-29 June 2013), and will be only briefly shown through images as they were presented at the conference. The proceedings of the conference are available on http://www.ecss.mobi/index.php?option=com_content&view=category&layout=blog&id=45&Itemid=90). Part of the results is unedited, and will be fully reported.
Student's t-test (paired or independent sample after applying f-test, two-tailed) was used to compare the different environmental conditions in the assessment study, and to investigate possible pre-existing differences between the groups (BASELINE). Linear Mixed model was used to investigate possible between-groups differences for all the study variables. 'Exercise session' (value measured in concomitance with the exercise day-1 and -2) or 'Follow-up time-point' (week-2 and -10 after the intervention) were set as Repeated variable. 'Identity' was chosen as type of covariance, in order to account for inter-individual differences. 'Group' (PAind and PAnat) and 'exercise session' were set as fixed factor in a factorial combination, and 'BASELINE' (the value of the corresponding variable at baseline) was set as a covariate, to avoid impacts of pre-existing differences between groups. Bivariate correlation (Pearson coefficient, two-tailed) was used to study the association across the different study variables at baseline and associations between post-exercise responses (e.g. affective responses and perceived restorativeness of the environment). A study of correlation was performed also to investigate possible associations between vit-D levels and different characteristics of the individuals at baseline. For the MLT values, a study of partial correlation was performed, controlling for age, gender and time in bed as these factors are likely to sensibly influence the nocturnal production.

The monitored variables were compared by paired t-test. The finding indicates that it was fairly possible to create similar workload conditions in the two environmental conditions, although it seems that the subjects tended to perceive the outdoor session as less demanding (see figure 4). As expected, the subjects tended to assign to the outdoor setting higher restorative qualities, with Fascination and Being Away scoring higher rates when the subjects exercised outdoors in nature (figure 5).

Examining the 'free text' wherein the subjects were asked to describe their feelings in connection with the biking and the surrounding, it seems that important elements of the PAnat setting contributing to perceived Fascination and Enjoyment were the variation of the scenario and the fresh air, which made the biking outdoors more 'fun' and 'rewarding', while on the contrary the indoor session was perceived as 'boring' and perceived that 'time was flowing more slowly' while biking indoors.

Examples:

"Comparing the indoor vs. outdoor setting, I definitely enjoyed the latter much more. During the indoor session I kept looking at the clock, looking forward to be finished. It was also difficult to indicate my RPE, because I could not really understand if I was physically exhausted or if I was just very bothered"

"With the same pulse / heart rate, I think the outdoor exercise was much easier. And much more rewarding. Time flew much faster than indoors"

"Indoors (…) time passed very slowly. (…) I was relaxed because stationary bike and did not think about the trail, but very bored because there wasn't something interesting in the room or some variation in views"

The subjects also tended to assign to the outdoor session higher ratings of Enjoyment, although no significant differences were found. It seems that this was mainly because some of the subjects thought that the indoor session was closer to their idea of training, where they can have more focus on controlling the exercise intensity and 'working-out hard', rather than taking an 'enjoyable bike-ride' or paying attention to balancing on the bike avoiding bumps on the track.

Examples:

"The indoor (setting) felt more like a structured training session compared to a "bike ride for fun" which the (outdoor setting) gave. The indoor gave more of an opportunity to focus on the pulse and getting in a mental groove. Yes more boring, but not having to focus on staying on the bike and crashing freed up more focus for training"

"Outdoor training was good because it provides fresh air, and I like to bike outdoors (…) but it was an easy trip, compare with other outdoor trips I've had experience of, both as length and difficulty. (The place chosen for the PAnat intervention) is not the natural area that fascinates me the most, but rather a good training ground for quick / fast workouts"

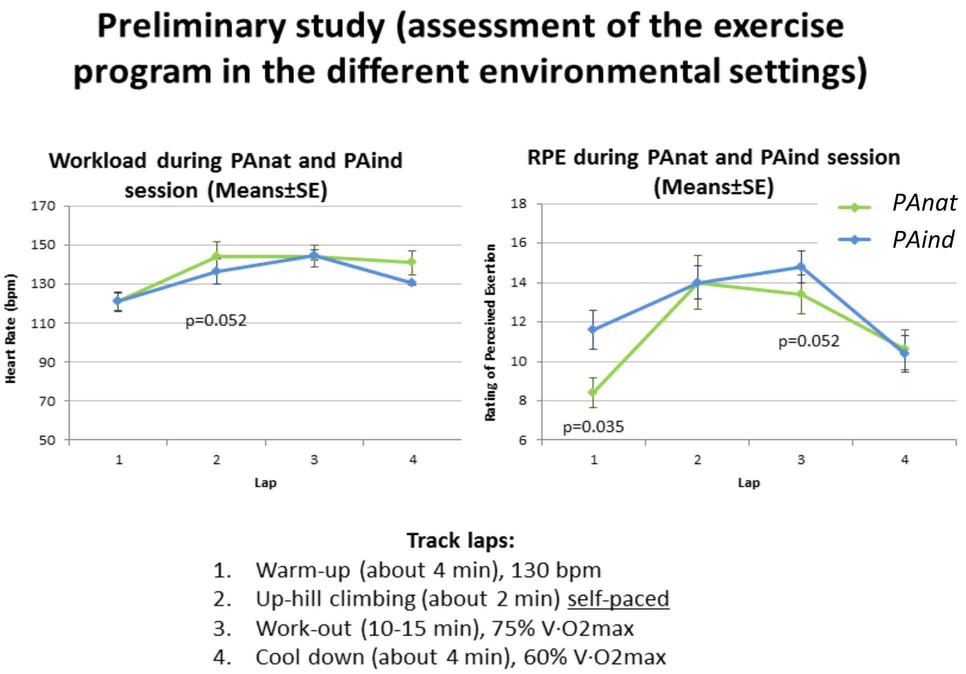


Figure 4. Workload (left) and perceived exertion (right) biking in the PAnat and the PAind setting (N=5, with the subjects undergoing both the experimental conditions)

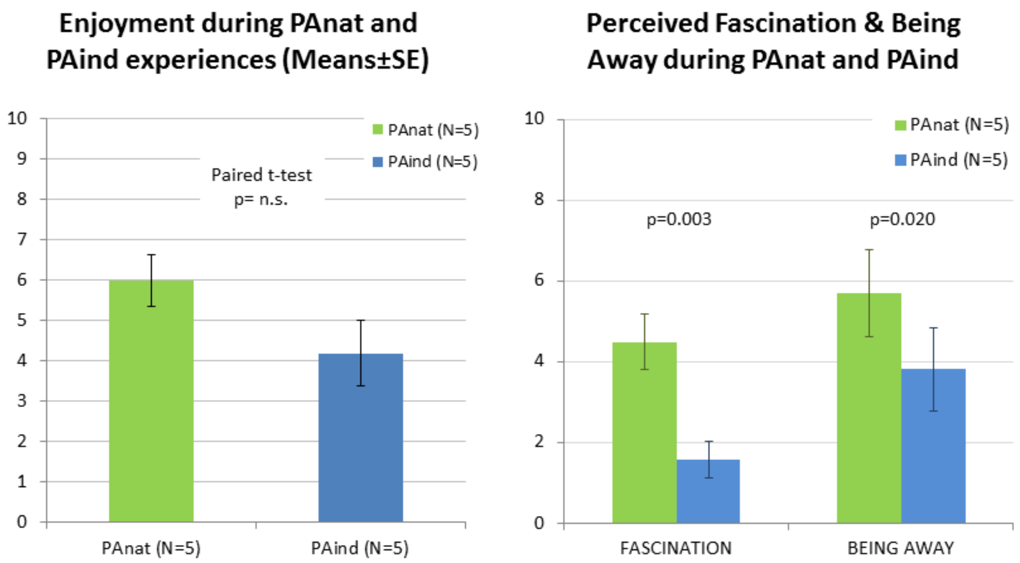


Figure 5. Enjoyment (left) and perceived restorativeness of the environment (right) biking in the PAnat vs. PAind setting (N=5, with the subjects undergoing both the experimental conditions)

THE *INTERVENTION STUDY*

PRELIMINARY MEASUREMENTS

The groups were fairly homogenous for what concern socio-demographic information, fitness and levels of PA (Table 1). We found that there were some differences in the PAAS profile, especially the PAnat group showed slightly lower levels of Negative Affect and Fatigue, compared to the PAind group. Yet, the values fall within healthy population.

The average levels of PA for the overall sample were fairly good (about 6.5 hours PA within a regular week, including walking and active transport), although there was quite a large inter-individual variability. One may also notice that the subjects who were assigned to the PAind group reported higher ratings of physical activity occurring in natural settings (EPE-nature), as compared to those who were assigned to the PAnat group.

A correlation study on the preliminary measurements highlighted that the individual score at the connectedness to nature scale (CNS) was positively associated with different parameters of physical activity, including fitness (Table 2). Furthermore, EPE nature was positively correlated with weekly amounts of PA (LTEQ hrs/week and LTEQ METs). Connectedness to nature (CN) is a personal disposition that has been previously found to be associated with healthy behaviours and wellbeing (Cervinka, Roderer, & Hefler, 2012). In our best knowledge, studies concerning the relationship between CN and PA have not been investigated yet. Although our findings are limited by a small sample size, therefore cannot at this stage be generalized, it is very plausible that ‘nature lovers’ are more prone to engage in outdoor activities, which contribute to the overall levels of PA and maintaining high fitness.

As described in the methods, light exposure was recorder by wrist actigraphy using Actisleep+ (Actigraph™, Pensacola, Florida) during the week-end preliminary the intervention (free PA) and during the week of the intervention (PA restricted). According to the product’s guideline, typical office lightning corresponds to 320-500 lux levels, while higher lux levels are likely to be due to exposure to natural sunlight (e.g. 400 lux for sunset/sunrise and 1000-6000 lux for an overcast day). Therefore, the higher the lux levels, the more likely the individual were directly exposed to sunlight. A statistically significant difference was found neither within nor between the subjects, and this could be due to a quite large inter-individual variability (see Standard Errors in table 3). Anyway, one may notice that the average light exposure tends to be higher for the PAind group compared to the PAnat during the week-end and the days the subjects were not engaged in the exercise intervention (table 3). This is in line with the self-reported EPE-nature, and support the fact that the PAind subjects were more prone to engage in physical activity outdoors in contact with nature. Anyway, the PAnat group tended to be more exposed to light in the days the exercise intervention took place. This might indicate that promoting PAnat intervention can improve the degree of sunlight exposure in employees who are typically working indoors.

Table 1. Sample's background description

	Average	SD	t-test between groups
Subjects	14 (7 in each group)		
Gender	50% females		n.s.
Age	49,21	8,00	n.s.
BMI	25,20	2,47	n.s.
marital status	8 are married/co-inhabitant		n.s.
Children	7 had small children home		n.s.
Education	1 upper-level education, 3 years higher education, 10 have > 3-years higher education		n.s.
Work occupation %	13 100% occupation, 1 50% occupation		n.s.
Smoker	2 smokers, 2 ex-smokers, 10 non-smoker		n.s.
CN	46,93	7,67	n.s.
MOOD:			
Positive Affect	2,88	0,71	n.s.
Tranquillity	2,80	0,59	n.s.
Negative Affect	0,26	0,42	0,03 (PAnat<PAind).
Fatigue	1,12	0,97	0,01 (PAnat<PAind)
LTEQ Hrs/week	6,46	4,51	n.s.
LTEQ MET/week	32,54	23,86	n.s.
LTEQ -item2	1,57	0,65	n.s.
VO2max* (fitness level)	3,64	0,84	n.s.
IAT	46,93	7,67	n.s.
EPE-indoors	2,00	1,15	n.s.
EPE-outdoor	1,07	1,49	n.s.
EPE-nature	3,50	1,45	0,04 (PAnat<PAind)

* $V \cdot O_{2max}$ absolute values were adjusted for and categorized for gender and age according to the Norwegian Health Ministry guidelines: 1= 'very low'; 2= 'low'; 3= 'middle/average'; 4= 'high'; 5= 'very high'; 6= 'top level'

CN= Connectedness to Nature.

LTEQ= Godin's Leisure Time Exercise Questionnaire, adjusted per hours/week. The version of the LTEQ used in this study included physical activity for active transport, such as bicycling/walking to work or other destinations.

LTEQ -item2= this item of the LTEQ is an analogue scale of self-reported frequency of engagement in physical activity: 1= OFTEN; 2= SOME TIMES; 3= SELDOM/NEVER.

EPE-indoors, -outdoors, -nature: Environmental Occurrence for Exercise in indoor settings, in outdoor semi-built environments, and in nature, respectively. The group exercising in the 'traditional' exercise setting scored higher occurrence of physical activity in natural environment compared to the group that exercised in the natural setting during the intervention.

IAT = Implicit association task for the determination of subjects' implicit attitude towards physical activity.

Table 2. Pearson Correlation: Connectedness to Nature & Physical Activity patterns

PA variables (preliminary measurement) N=14	**Connectedness to Nature (CNS)**	
	r **(Pearson)**	***p*** **(2-tailed)**
Fitness	,56	,039
METs	,48	,082
Steps Average Counts	,63	,013
IATPA	,49	,076
LTEQ hrs/week*	,58	,031
LTEQ item-2*	-,69	,006
EPE nature*	,51	,067

Fitness: output of the VO_2max test adjusted for age and gender;

METs and *Steps Average Counts*: calculated on actigraphy outputs;

LTEQ hrs/week: hours/week spent in PA (score at the LTEQ);

LTEQ METs: PA levels in METs/week (score from LTEQ);

LTEQ item 2: frequency of moderate to intensive PA (1= seldom-never; 2= sometimes; 3= often/daily);

*EPE nature was positively correlated with LTEQ hrs/week (r=0.571; p= 0.033) and LTEQ METs (r=0.55; p=0.042).

Table 3. Daily light exposure (lux measured by ActiGraph® device; time-window 6:00-18:00) during week-end, regular working day (PA restricted) and during days engaged Estimated Marginal Means).

3. Group * Condition[a]

Group	Condition	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
INDOOR	Week-end	258,433	40,810	102	177,487	339,380
	Working day	122,631	58,813	102	5,975	239,287
	PA intervention	92,605	56,674	102	-19,807	205,018
NATURE	Week-end	97,408	41,587	102	14,919	179,896
	Working day	80,914	56,674	102	-31,498	193,327
	PA intervention	91,146	56,674	102	-21,266	203,559

a. Dependent Variable: Lux Average Counts.

Week-end (Friday-Saturday-Sunday): During the week-end the participants were free to engage in any activity.

Work-days (Thursday-Monday-Wednesday)*:* during these the participants were partly asked to restrict their physical activity to the exercise proposed in the seminar. Especially, those participating in the indoor group were asked to avoid outdoors activities such as running or biking to work.

PA intervention: (Tuesday-Thursday) in these days the subjects participated in the exercise program proposed within the intervention, divided in two groups exercising in the different environmental settings (gym-hall and neighbourhood forest).

MEASUREMENTS OF THE PHYSICAL EXERTION

The days of the experimentation we had excellent weather conditions (sunny and clear-sky the first exercise day and overcast but clear the second exercise day), with temperature around 10°C. The temperature recorded in the PAind setting was 20°C.

One may notice that HR tends to be higher for the PAnat subjects during the baseline measurement before the exercise session (figure 6). This may be due to thermoregulation response to the colder environment in the outdoor setting. The HR outputs showed that the exercise intensity was moderate-to-intensive (70-80% of individuals' HR_{max}). The PAnat and PAind were fairly equivalent in terms of physical workload, although the PAnat tended to have higher HR while biking (figure 6). Though, such a difference might be somehow expected since, as compared to biking on an indoor bike, biking on road requires a greater muscular intervention for balancing. Comparisons by t-test did not highlight significant differences in HR recovery values (post-exercise).

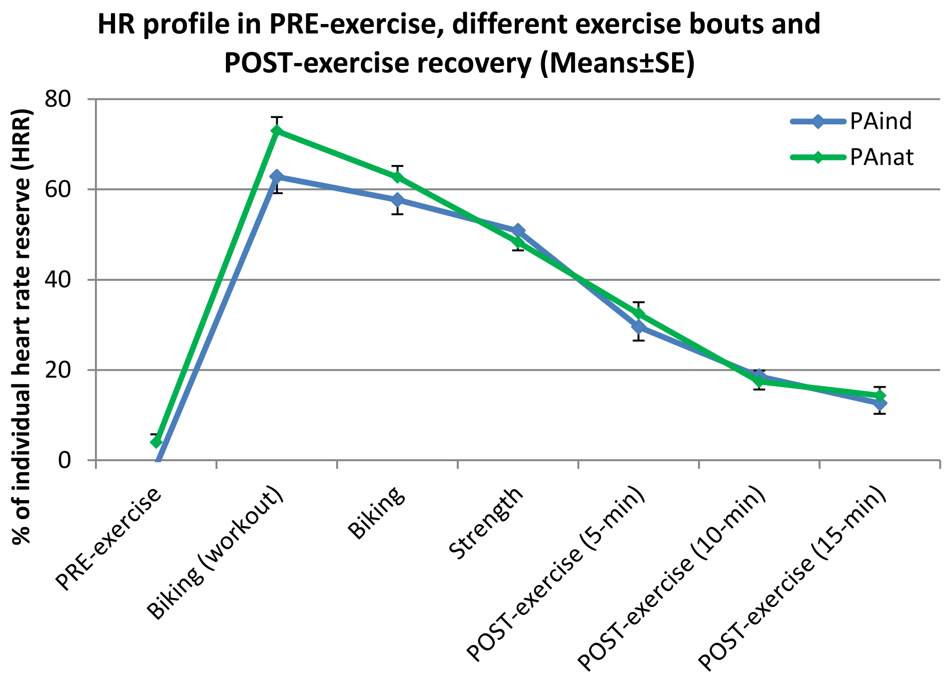


Figure 6. HR profile in 14 subjects participating in a PAnat or PAind exercise program (average of two exercise sessions). **'***PRE-exercise'= HR monitoring with the subjects laying in semi-supine position (average of 5-min, after 5-min of stabilization); 'Biking (workout)'= average of the HR recorded during the most intensive part of the biking bout (15-min); 'Biking'= average of HR recorded during the overall biking bout, including warm-up and cool-down; 'Strength'= average of HR recorded during the overall strength bout (20-min); POST-exercise: the POST-exercise recovery is shown in three phases, including 5-min whilst the subject filled in the questionnaires and prepared for the actual HR monitoring, 5-min of stabilization in semi-supine position and 5-min of actual monitoring in semi-supine position.*

PSYCHOLOGICAL RESPONSES TO THE EXERCISE AND MOTIVATION TO EXERCISE

The results of the quantitative analyses have been presented in two e-poster presentations at the 18th Annual Conference of the European College of Sport Science, Barcelona, 25-29 June 2013 (G. Calogiuri et al., 2013; Calogiuri, Nordtug, Weydahl, & Patil, 2013).

We hereby report the posters have they have been presented at the conference (figure 7 and 8). The text of the abstracts published in the conference proceedings is available on http://www.ecss.mobi/index.php?option=com_content&view=category&layout=blog&id=45&Itemid=90

Examining the subjects' feedbacks in open question at week 2 and 10 of the follow-up (data not presented at the ECSS) wherein the subjects were asked to describe their feelings in connection with the PA and the environment, it was found that the PAnat group perceived the exercise-program enjoyable and motivating.

Examples:

1. "Inspiring, especially to learn about strength training with rubber bands"

2. (Week 2) "After I got kids my life was mainly dedicated to the family, house and job. Now my children have grown up and I have been thinking for a long time that I should exercise more regularly. This intervention has made me become more motivated. The training sessions were fun (...) out in the fresh air and beautiful natural surroundings. (...) Strength training with elastic was new to me, but it was really fun and is something that I will continue. Thanks for letting me be a part of the project" (Week 10) "It was fun to be part of the project; I've actually started to exercise more after I was 'helped' ☺"

3. (Week 2) "Exercising in the outdoor surrounding was very good" (Week 10) "It was a 'good kick' to motivate me to be physically active. I cycle to work every day, even now in the winter"

On the other hand, the participants in the PAind tended to perceive the exercise as 'boring' without presence of other entertainment such as music of television. Though, they reported to be satisfied of the information received during the overall intervention.

Examples:

1. "Training inside is probably not for me. I rather prefer to engage in activities such as going out in nature and terrain alternative"

2. "The cycling was very boring. No entertainment such as movies or music. Otherwise I thought it was interesting to participate (in the intervention). The instructors were inspiring (...). Positive experience overall"

3. "I was interested to participate in the intervention and I'm especially pleased to have undergone the fitness test (...). I needed some individual training tips based on 'how my form is now'. Though, I felt the training sessions were short and cycling indoors was very little engaging"

Psycho-physiological responses to a standardized exercise program

INDOORS VS. NATURAL ENVIRONMENT: preliminary results from a pilot study. Part I:

AFFECT & PERCEIVED RESTORATIVENESS OF THE ENVIRONMENT

G. Calogiuri[1], K. Evensen[1], G. Patil[1], C.M. Ihlebæk[1], R.K. Raanaas[1] and A. Weydahl[2]

Introduction

Natural environments have been reported to elicit restoration from mental fatigue and psychophysiological stress (Kaplan, 1995). Higher ratings of perceived restorativeness of the environment in connection with experiences in natural environments have been associated with enhanced cognitive performance (Hartig, 1991). Physical activity in contact with nature, e.g. walking in green spaces, have been associated with positive mental states, although the effects of 'green exercise' on mental health are still debated (Thompson Coon et al., 2011). In a pilot study, *we investigated the effects of engaging in a standardized exercise program outdoors in natural environment, as compare to an indoor setting, on affective responses and perceived restorativeness of the environment.*

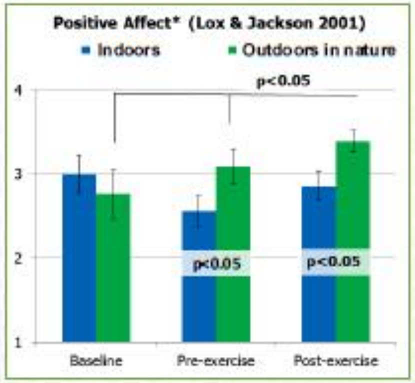
Methods

Subjects: Healthy adults, 7 males and 7 females (age 48.5+/-7.3 yr; BMI 25.4+/-2.45; VO2max 39.8+/-7.7 ml/min/kg), semi-randomized to the indoor or the outdoor group

Intervention: Two exercise sessions within 1-week, each consisting in 25-min biking (60.1+/-7.9 %HRR) and 20-min circuit strength training with rubber bands (49.7+/-9.6 %HRR).

Protocol & Instruments: Connectedness to nature scale (CNS; Mayer & Fratz, 2004) was administered preliminary the intervention. Physical Activity Affective Scale (PAAS; Lox & Jackson 2001) was administered at baseline (one week before the intervention, in no-exercise conditions) and pre- and post-exercise. Subscales of the Perceived Restorativeness Scale (PRS, Fascination and Being Away; Hartig et al., 1997) was administered at completion of each exercise session. Heart rate (HR) and ratings of perceived exertion (RPE; Borg, 1982) were measured during the exercise sessions to estimate the workload.

Statistics: Estimates of fixed effect 'group' by linear mixed model, with 'session' and 'pre-post' set as repeated measure (type of covariance= identity). Students' t-test was used to compare PAAS ratings at different time-points (baseline, pre- and post-exercise). A study of correlation (Pearson, two tailed) was eventually performed.



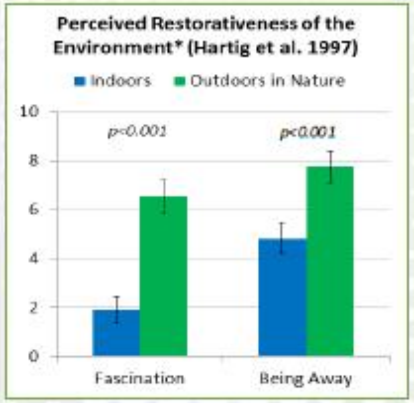


Figure 1 (above) and 2 (below). *Means±SE (average of two exercise session)

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Results

No significant differences between groups were found for CNS, and the overall workload (HR and RPE) was fairly even in the two exercise-environments. Significant differences across groups were found for PRS (both *Fascination* and *Being Away*) and Positive Affect, with higher ratings for the outdoor group (table 1). A study of correlation showed that post-exercise Positive Affect was associated with both Fascination (r=0,69; p<0,01) and, especially, Being Away (r=0,81; p<0,01), while it was negatively associated with post-exercise Fatigue (r=-0,53; p<0,05). No significant correlation was found between CNS and components of PAAS or PRS.

Table 1. Outputs of the linear mixed model on components of affective response and Perceived Restorativeness of the Environment during exercise sessions indoors vs. outdoors in natural environment (N=14)

Variable	p	Estimate difference (±SE)*	t	95% C.I. of the difference Variable	
Perceived Restorativeness					
Fascination	<0.001	-4.64±0.61	-7.62	-5.89	-3.39
Being Away	<0.001	-2.93±0.56	-5.20	-4.90	-1-77
Affective Response					
Positive affect	<0.001	-0.63±0.11	-5.72	-0.85	-0.41
Neg. affect	n.s.				
Fatigue	n.s.				
Tranquility	n.s.				

**Group 1 = INDOOR; Group 2 = OUTDOOR. Negative values indicate higher ratings for the OUTDOOR group*

Discussion

As compared to exercising indoors, exercising in natural environment was associated with greater affective responses and opportunities to restore from mental fatigue. These results provide further confirms on the positive effects of exercising in natural environments on indicators of mental health, beyond exercising in 'traditional' indoor settings. The novelty of this study consists in investigating the association between affective responses and perceived restorativeness of the environment in connection with a complex exercise program of moderate-to-vigorous intensity. More studies on larger sample and including different environmental variables are recommended.

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Figure 7. CALOGIURI, G., EVENSEN, K., PATIL, G., IHLEBÆK, C., RAANAAS, R., & WEYDAHL, A. (2013, 26-29 JUNE 2013). PAPER PRESENTED AT THE 18TH ANNUAL CONFERENCE OF THE EUROPEAN COLLEGE OF SPORT SCIENCE (ECSS), BARCELONA, SPAIN. #PP-PM17-10

Psycho-physiological responses to a standardized exercise program

INDOORS VS. NATURAL ENVIRONMENT: preliminary results from a pilot study. Part II:

MOTIVATION TO EXERCISE

Calogiuri G.[1], Nordtug H.[2], Weydahl A.[3] and Patil G.[1]

Introduction

Being outdoors in natural environments has been associated with vitalization (Ryan et al., 2010), which may improve individuals' attitude towards physical activity and elicit active lifestyles. *As a pilot study, we have studied the impact of exercising in two different environmental settings (indoors vs. outdoors in a natural environment) on motivation to engage in physical activity (PA).*

Methods

Subjects: Healthy adults, 7 males and 7 females (age 48.5+/-7.3 yr; BMI 25.4+/-2.5; VO2max 39.8+/-7.7 ml/min/kg), semi-randomized to the indoor or the outdoor group

Intervention: Two exercise sessions within 1-week, each consisting in 25-min biking (60.1+/-7.9 HRR%) and 20-min circuit strength training with rubber bands (49.7+/-9.6 HRR%).

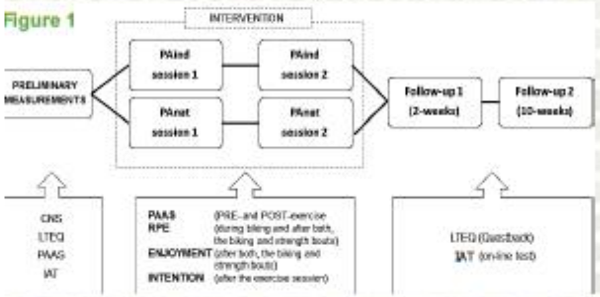
Protocol & Instruments (Fig. 1):

Preliminary the intervention: Connectedness to Nature Scale (CNS; Mayer & Fratz, 2004), an adjusted version of Leisure Time Exercise Questionnaire (LTEQ; Godin, 1985), and Implicit attitude towards PA by implicit association test (IAT; Greenwald et al. 1998).

During the exercise sessions: Percent of HR Reserve (HHR%), Ratings of Perceived Exertion (RPE; Borg, 1982), and Enjoyment after the biking and the strength bouts (single-item scale). Physical Activity Affective Scale (PAAS; Lox & Jackson 2001) and Intention to exercise in future (3-items scale) were measured at completion of each exercise session..

Follow-up (2- and 10-weeks after the intervention): IAT and LTEQ, including specific PA proposed during the exercise-intervention.

Figure 1



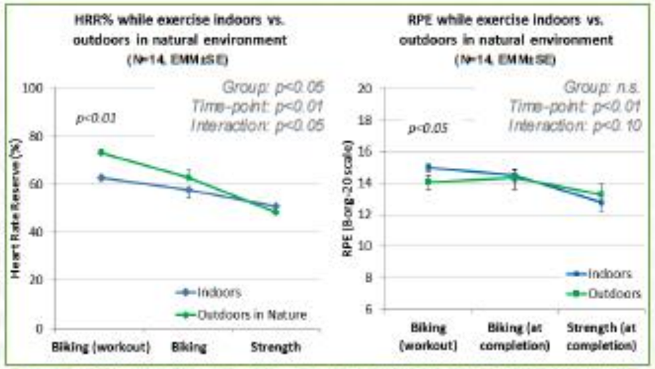


Figure 2. *Biking (workout)= intensive part of the biking bout; Biking= overall biking bout (including warm-up and cool-down); Strength= overall circuit strength bout.* ***Linear Mixed Model:*** *Subjects='Subject ID'; Repeated='time-point' (workout, biking and strength); Covariance type= 'identity'.*

Table 1. Estimates of fixed effect 'group' by linear mixed model (N=14)

Variable	Estimate difference (±SE)[a]	t	p	95% C.I. of the difference		Eta Squared
Enjoyment (biking)	-2.93±0.73	-4.01	<0.001	-4.43	-1.43	0.57
Enjoyment (rubber-bands)	-1.71±0.80	-2.15	0.04	-3.36	-0.07	0.28
PAAS[b]						
- Positive affect	-0.63±0.11	-5.72	<0.001	-0.85	-0.41	0.73
- Negative affect			n.s.			
- Fatigue			n.s.			
- Tranquility			n.s.			
Intention[c]	-0.78±0.35	-2.21	0.04	-1.52	-0.05	0.29

[a] *group 1 (INDOOR) – group 2 (OUTDOOR).*
[b] *Components of PAAS were adjusted for individuals rating at baseline*
[c] *Intention to exercise was adjusted for individual PA ratings (LTEQ score)*

Linear Mixed Model: *Subjects='Subject ID'; Repeated='Exercise session' and, for PAAS components, 'PRE-POST'; Covariance type= 'identity'; Fixed factor: 'group'.*

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Results

The workload was fairly even in the two exercise settings, although the outdoor group tended to report lower RPE and higher HRR% in the most intensive part of the session (Fig. 2). A significant effect across groups was found for Enjoyment, Positive Affect and, when adjusted for LTEQ, Intention to exercise in future. For all variables there were higher ratings for the Outdoor than the Indoor group (Table 1). CNS was independently correlated with LTEQ (r=0.57), IAT (r=0.49) and Intention to exercise in future (r=0.86).

Follow-up: No significant changes in IAT and time spend on PA in general (LTEQ) were found. However, the outdoor group scored marginal significantly higher for specific PA, i.e. 'biking in natural settings' (p=0.05) and 'exercise with rubber-bands' (p=0.06) (Fig. 3)

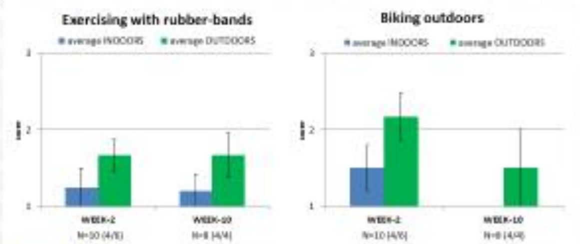

Figure 3. *Frequency of exercising with rubber-bands and biking outdoor at follow up. 1= seldom/never; 2 sometimes; 3 often. N in brackets indicates number of subjects who participated in the indoor/Outdoor intervention, respectively.*
Linear Mixed Model: *Subject: 'Subject ID'; Repeated='time-point' (week-2 and -10); Covariance type= 'identity'; Fixed factor: 'group'.*

Discussion

Natural environments can offer the opportunity to make exercise being perceived as more enjoyable and less fatiguing, impacting behavioral intention to engage in exercise. Interventions promoting PA in natural environments may have a stronger impact on people's motivation to exercise. Yet, further studies are needed.

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Figure 8. **CALOGIURI, GIOVANNA, NORDTUG, HILDEGUNN, WEYDAHL, ANDI, & PATIL, GRETE. (2013, 26-29 JUNE 2013). PAPER PRESENTED AT THE 18TH ANNUAL CONFERENCE OF THE EUROPEAN COLLEGE OF SPORT SCIENCE (ECSS), BARCELONA, SPAIN. #PP-PM17-9**

MARKERS OF PSYCHOPHYSIOLOGICAL STRESS

I. AUTONOMIC CONTROL

These results have been presented as an e-poster presentation at the 18th Annual Conference of the European College of Sport Science, Barcelona, 25-29 June 2013 (Mikkila, Calogiuri, Patil, & Weydahl, 2013).

We hereby report the poster has it was presented at the conference (figure 9). The text of the abstract published in the conference proceedings is available on http://www.ecss.mobi/index.php?option=com_content&view=category&layout=blog&id=45&Itemid=90

Psycho-physiological responses to a standardized exercise program
INDOORS VS. NATURAL ENVIRONMENT: preliminary results from a pilot study.
Part III: CARDIOVASCULAR MODULATION

Mikkilä S.[1], Galogiuri G.[2], Patil G.[2] and Weydahl A.[1]

Introduction

It has been suggested that exercising in contact with nature may provide health benefits beyond exercising elsewhere, but evidences of the effects of green exercise on physical health are yet scarce (Thompson Coon et al. 2011). Stress-relieving effects, such as decreased blood pressure (BP) and improved vagal cardiac modulation, of being and walking in nature has been shown in previous studies (Park et al. 2010). Also, effects of viewing images of nature on heart rate variability (HRV), reflecting the status in the autonomic nervous system (ANS) and being related to cardiovascular health, has been indicated (Gladwell et al. 2012).

Therefore, the aim of the study was to investigate effects of the outdoor exercise in contact with nature on physical health, i.e. biomarkers of psycho-physiological stress, in comparison to indoor exercise.

Methods

Fourteen healthy adults, 7 males and 7 females (age 48.5±7.3 yr; BMI 25.4±2.5; VO_{2max} 39.8±7.7 ml/min/kg), were semi-randomized to the indoor or the outdoor group. Subjects performed two exercise sessions within 1-week in one of the environmental settings: indoors (gym hall) or outdoors in a natural setting (Figure 1). Each session consisted in 25-min biking (60.1±7.9 HRR%) and 20-min circuit strength training with a rubber band (49.7±9.6 HRR%). Also, the subjects were prohibited from engaging in any additional physical training during the protocol.

Baseline measurements of HRV and BP were performed after the subjects abstaining from exercise for at least 48-hours. After both exercise sessions, beat-to-beat intervals were recorded overnight with a HR-monitor belt, and BP was measured the following morning. The baseline and the second exercise session occurred in same weekdays (Friday) of consecutive weeks. A 5-minute sequence during the estimated first slow wave sleep (Brandenberger et al. 2005) was isolated for the HRV frequency analyzes. Outputs were analyzed by linear mixed model and the values were adjusted for the individual baseline (no exercise for 48-hours).

Figure 1. Environmental settings for the study; outdoor setting on the left and indoor setting on the right.

Results and discussion

Diastolic BP was significantly lower ($p=0.018$) the morning following the outdoor exercise sessions (Figure 2). A tendency to lower values was observed also for the systolic BP, although significance vs. the indoor group was not achieved. The poor quality of the overnight beat-to-beat monitoring did not allow us to include all the subjects in the analysis. Only 8 subjects had a complete set of monitoring including baseline and both post exercise recordings. The missing data for 4 subjects (1 of 3 measuring points) was imputed according to Snedecor & Cochran (1971 pp. 317-318).

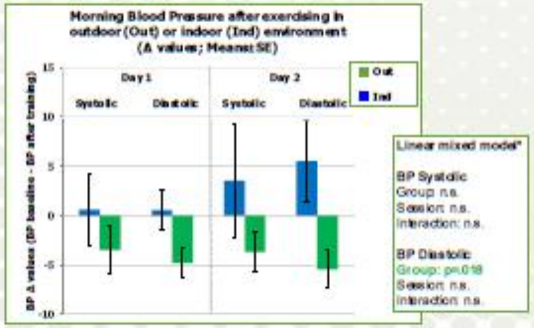

Figure 2. Post-exercise BP parameters (difference between post-exercise and baseline), in outdoor and indoor environments.
* Linear Mixed Model: Repeated= 'exercise session'; Type of covariance= 'Identity'; BP values at baseline were set as covariates.

There was no significant difference between groups for the nocturnal HRV after exercise sessions. However, significant effect of exercise on the nocturnal HRV individually was found. Figure 3 exemplifies HRV results (N=12) by indexes of the modulation of the sympathetic branch (LFnu) and the parasympathetic branch (HFnu) of the ANS. Both groups show the same effect pattern, increased parasympathetic and decreased sympathetic cardiac modulation. Although, no significant difference between the groups was found, these results suggest a positive effects of exercise regardless of environmental settings.

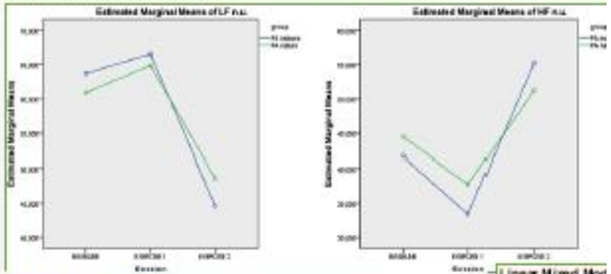

Figure 3. Linear mixed model of the nocturnal HRV parameters, LFnu and HFnu, in baseline and post-exercise, in outdoor and indoor environments.
*Linear Mixed Model: Statistics outputs refers to both, LFnu and HFnu. Post-exercise values were adjusted for individual baselines.

Conclusions

The main finding of the study was that there was a significant effect to the diastolic BP the morning after training sessions outdoors. Therefore, green exercise may positively impact the cardiovascular modulation, with possible benefits in the long term, such as lower BP values. Also, due to challenges with the overnight HRV monitoring, studies on larger samples are recommended.

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Figure 9. MIKKILA, S., CALOGIURI, G., PATIL, G., & WEYDAHL, A. (2013, 26-29 JUNE 2013). PAPER PRESENTED AT THE 18TH ANNUAL CONFERENCE OF THE EUROPEAN COLLEGE OF SPORT SCIENCE (ECSS), BARCELONA, SPAIN. #PP-PM12-9

Markers of Psychophysiological Stress

II. Activation of the HPA-axis: Cortisol Levels

These results have been presented as an oral presentation at the 18th Annual Conference of the European College of Sport Science, Barcelona, 25-29 June 2013 (Mikkila, Calogiuri, Weydahl, & Patil, 2013).

We hereby report some images extracted from the slides presented at the conference (figure 10.a, 10.b, 10.c, and 10.d). The text of the abstracts published in the conference proceedings is available on http://www.ecss.mobi/index.php?option=com_content&view=category&layout=blog&id=45&Itemid=90

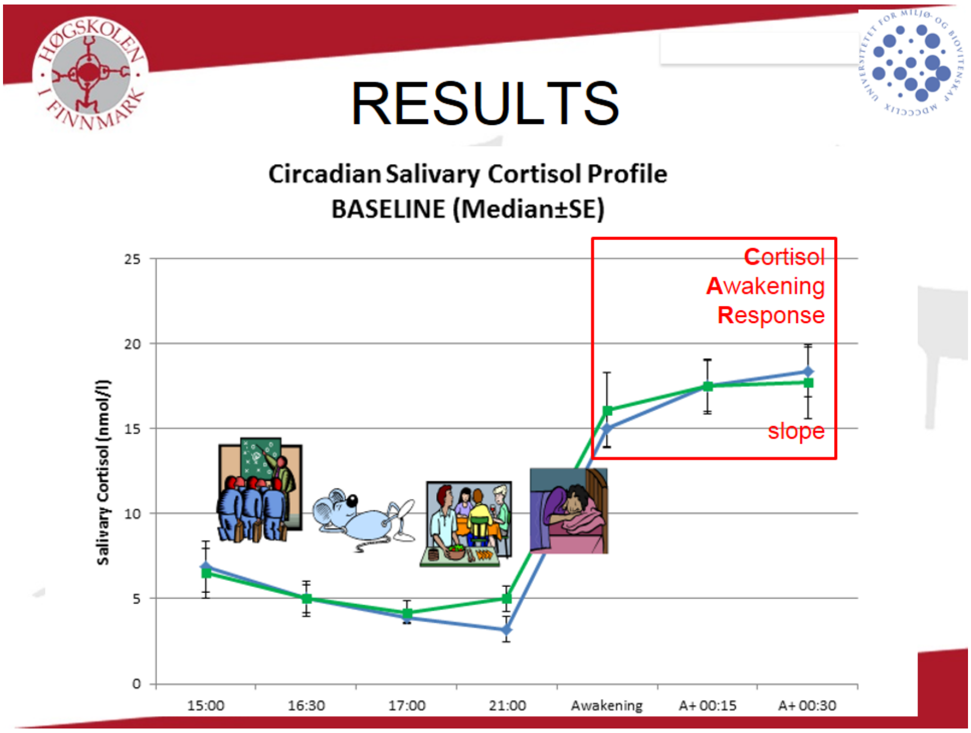

Figure 10.a: Circadian profile of salivary cortisol for PAnat (green line; N=7) and PAind (blue line; N=7) at baseline (no exercise for at least 48-hrs ahead of time)*

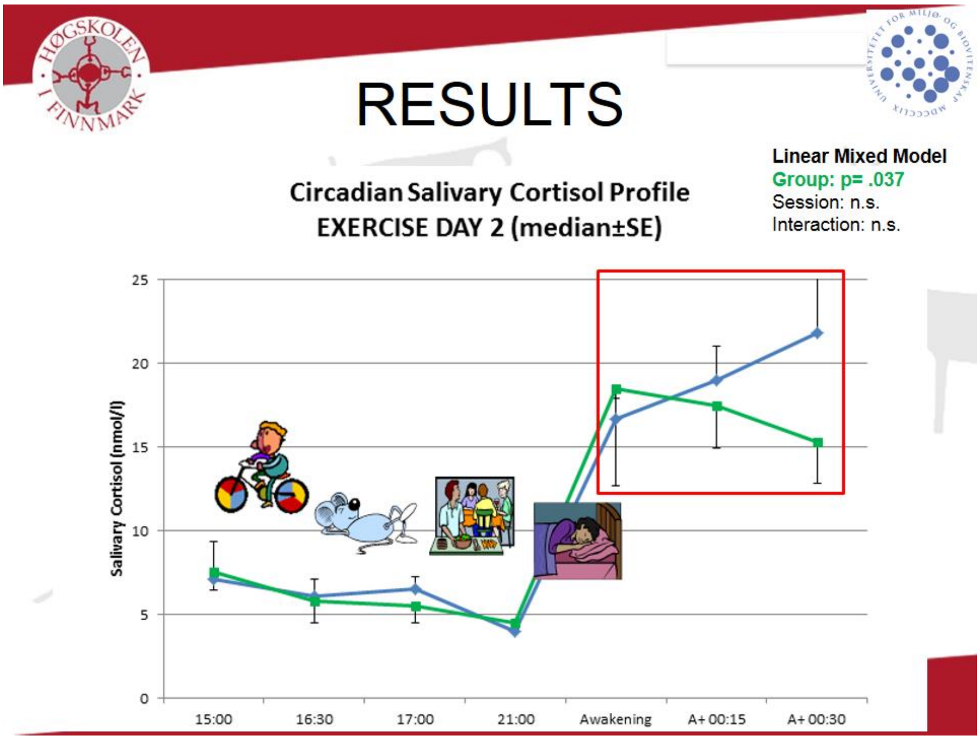

Figure 10.b: Circadian profile of salivary cortisol for PAnat (green line; N=7) and PAind (blue line; N=7) in concomitance with the exercise intervention*

*MIKKILA, S., CALOGIURI, G., PATIL, G., & WEYDAHL, A. (2013, 26-29 JUNE 2013). PRESENTED AT THE 18TH ANNUAL CONFERENCE OF THE EUROPEAN COLLEGE OF SPORT SCIENCE (ECSS), BARCELLONA, SPAIN. #OP-PM09-3

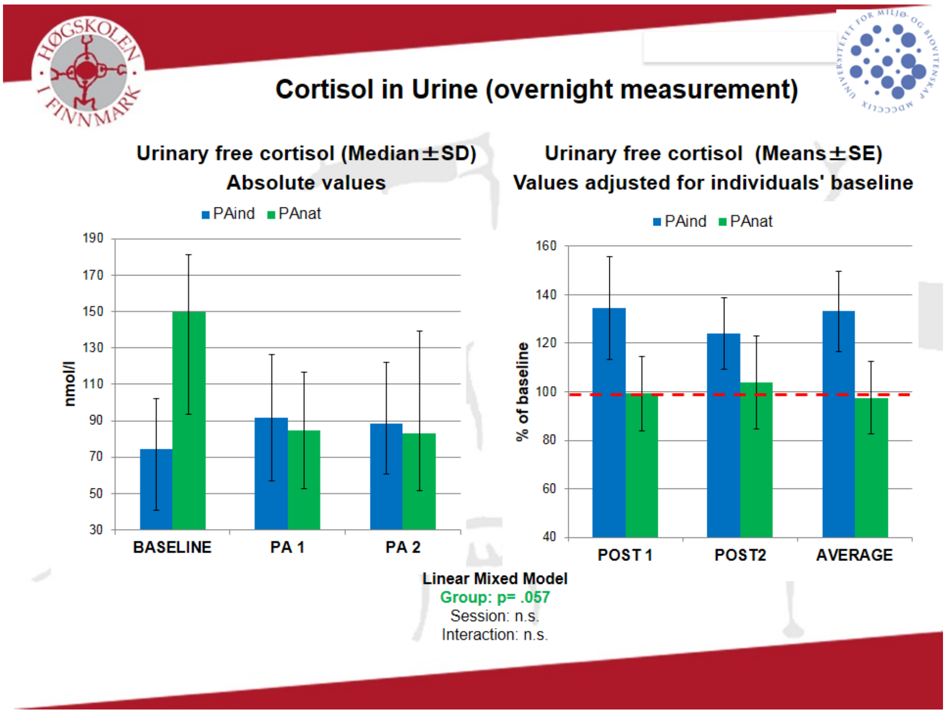

Figure 10.c: Overnight free cortisol level in urine (18:00-08:00), in PAnat (green columns; N=7) and in PAind (blue columns; N=7), at baseline (no exercise for at least 48-hrs ahead of time) and the morning after the exercise intervention. Statistics refer to absolute values*

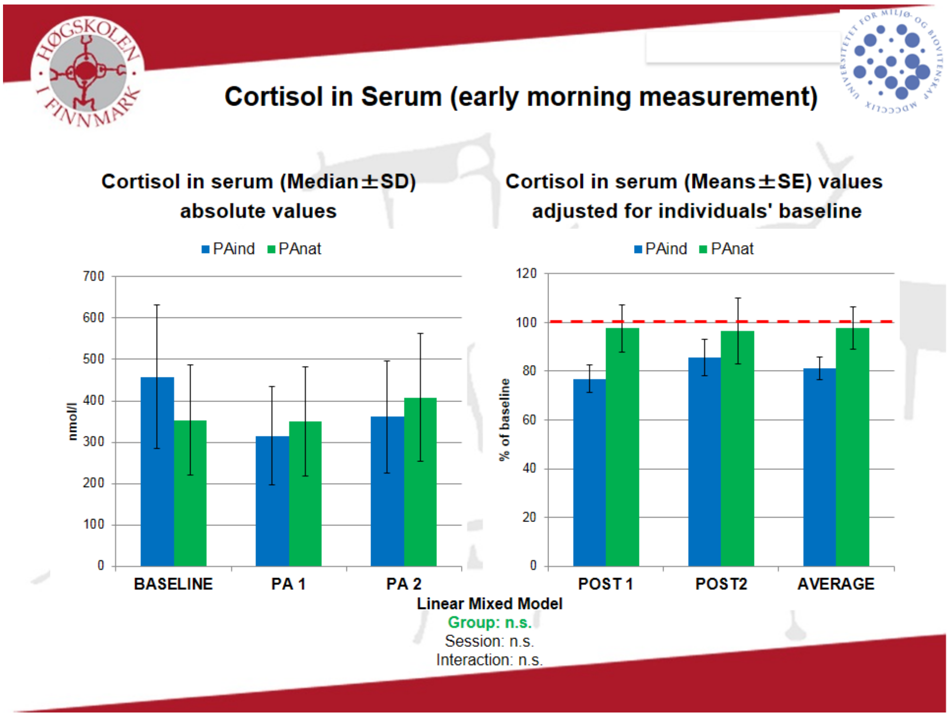

Figure 10.d: Cortisol level in serum (early morning), in PAnat (green columns; N=7) and in PAind (blue columns; N=7), at baseline (no exercise for at least 48-hrs ahead of time) and the morning after the exercise intervention. Statistics refer to absolute values *

*MIKKILA, S., CALOGIURI, G., PATIL, G., & WEYDAHL, A. (2013, 26-29 JUNE 2013). PRESENTED AT THE 18TH ANNUAL CONFERENCE OF THE EUROPEAN COLLEGE OF SPORT SCIENCE (ECSS), BARCELLONA, SPAIN. #OP-PM09-3

BIOLOGICAL RHYTHMS AND SLEEP (MELATONIN LEVELS AND REST-ACTIVITY RHYTHM)

No significant changes in connection with the PAnat intervention were observed in the overnight urinary MLT levels. One may notice that the PAnat group showed higher MLT levels already in BASELINE. Overnight MLT tended to increase after the exercise sessions (PA 1 and PA 2) for both groups, with not evident differences between groups. Such findings are in line with previous studies showing increased overnight MLT levels following exercise (Knight et al., 2005) (Figure 11; table 4).

An overall significant difference between groups was found, with higher values for the PAnat subjects, but an effects of the exercise intervention was not found. This can be probably explained by pre-existing between-groups differences (see MLT values in BASELINE).

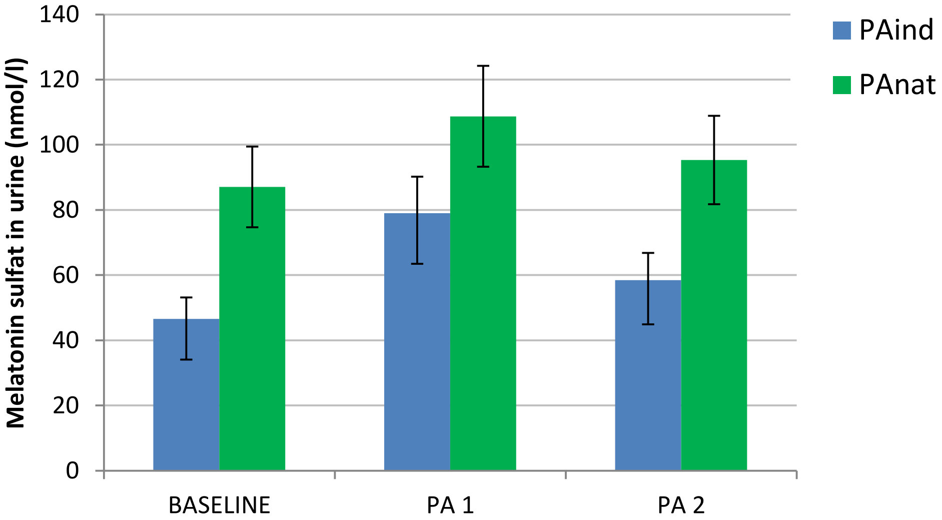

Figure 11. Overnight Melatonin levels in 14 participants in a PAnat or PAind exercise-intervention (Means±SE).

PA 1 and PA 2= exercise day 1 (Tuesday) and exercise day 2 (Thursday), respectively.
Average Time in bed: *BASELINE*= (PAind) 22:50±00:58 (PAnat) 23:13±00:51; *PA-1*= (PAind) 22:56±00:54 (PAnat) 22:52±1:21; *PA-2*= (PAind) 22:36±00:32 (PAnat) 23:35±00:33.
Average out of bed time: *BASELINE*= (PAind) 6:10±00:38 (PAnat) 6:55±00:59; *PA-1*= (PAind) 06:26±00:31 (PAnat) 06:19±00:58; *PA-2*= (PAind) 06:13±00:33 (PAnat) 06:50±00:31.

Table 4. Overnight Melatonin levels (estimated marginal means) in 14 participants in a PAnat or PAind exercise-intervention.

group * timep[a]

group	timep	Mean	Std. Error	df	95% Confidence Interval	
					Lower Bound	Upper Bound
INDOOR	BASELINE	46,529	16,596	36	12,870	80,187
	PA 1	78,986	16,596	36	45,327	112,644
	PA 2	58,486	16,596	36	24,827	92,144
NATURE	BASELINE	87,071	16,596	36	53,413	120,730
	PA 1	108,729	16,596	36	75,070	142,387
	PA 2	95,357	16,596	36	61,699	129,016

a. Dependent Variable: MLT.

VITAMIN D

Significant differences in 25-OH-vitD levels were found neither between groups nor across sessions. Again a large inter-individual variability was observed among the subjects, with only three subjects showing values below the minimum recommended levels (50 nmol/l) and only two subjects achieving the optimum recommended levels (70 nmol/l) in the baseline measurement

An significant effect of the exercise intervention was not found (figure 12 and table 5). The intervention took place in North Norway in September, between 15:00 and 16:30. In that period of the year and that time of day the sun rays were probably not strong enough to have a relevant impact on the vitamin D production. Furthermore, because of the low temperature (about 10°C), the subjects participating in the PAnat program had arms and legs completely covered by clothing, and some even wore gloves. Therefore, it is likely that the interventions did not provide a condition good enough to enhance the participant's production of vitamin D.

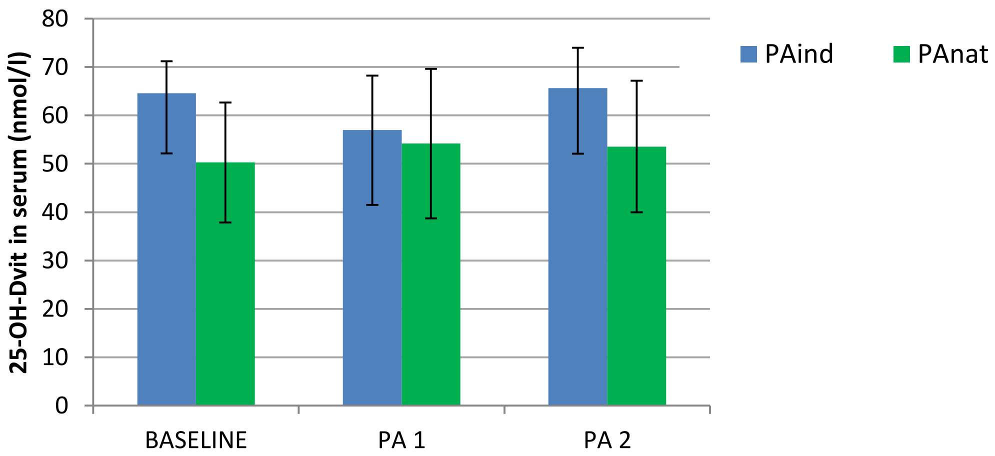

Figure 12. Vitamin-D levels (Means±SE) in 14 participants in a PAnat or PAind exercise intervention.

PA 1 and PA 2= exercise day 1 (Tuesday) and exercise day 2 (Thursday), respectively.

Table 5. Vitamin-D levels (estimated marginal means) in 14 participants in a PAnat or PAind exercise intervention.

group * timep[a]

group	timep	Mean	Std. Error	df	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
INDOOR	BASELINE	64,566	5,874	35	52,641	76,491
	PA 1	57,000	5,874	35	45,075	68,925
	PA 2	65,649	5,874	35	53,724	77,574
NATURE	BASELINE	50,265	5,874	35	38,340	62,189
	PA 1	54,165	6,345	35	41,284	67,045
	PA 2	53,561	5,874	35	41,636	65,485

a. Dependent Variable: VitD.

SECTION IV
DISCUSSIONS, CONCLUSION AND PERSPECTIVES

Final discussions & Conclusions

Natural environments and urban green spaces provide opportunities to engage in a multitude of physical activities, and their importance in public health have been advocated (Bedimo-Rung et al., 2005). Besides offering spaces and features for exercising, natural environments can encourage people to stroll or hike, or to engage in *active transport* (traveling without the mean of a motorized vehicle, e.g. walking or biking). Although several studies have shown a positive associations between availability of green spaces within the living environment and ratings of PA, yet it is not clear what is the impact of the natural environments on peoples motivation to engage in PA (A. C. K. Lee & Maheswaran, 2011).
There is an abundance of evidences showing that engaging in PA outdoors in contact con nature might lead to health benefits beyond and above engaging in PA elsewhere (e.g. indoors). Health advantages of engaging in PA in contact with nature have been described especially on indicators of mental health (e.g. mood and self-esteem), but also on indicators of organic stress (e.g. stress hormones and HRV). Though, the findings concerning the impact of *green exercise* on physical health remain somehow inconclusive (Bowler et al., 2010).

The pilot study presented in this report aimed to investigate the impact of *green-interventions* on individual motivation to commit to exercise and further health advantages in the long term, in the attempt to extend and fill the gaps in the current literature.

Research question 1: *Does PAnat elicit greater positive subjective experiences of PA and affective responses to exercise, positively impacting future motivation to exercise?*

It was found that, as compared to the PAind, the subjects who participated in the PAnat (both, in the assessment study and in the actual intervention study) tended to report lower ratings of perceived exertion with even or higher HR values, and higher ratings of Enjoyment. Furthermore, the employees participating in the PAnat intervention reported higher ratings of post-exercise Positive Affect (hypothesis 1). These results confirm and enrich previous findings for what concern the effects of *green exercise* on psychological responses to PA (Thompson Coon et al., 2011).
Some argue that the role of emotions is to give feedback to the individual on which activities to pursue or not (Baumeister, Vohs, DeWall, & Zhang, 2007). Thus, the greater Positive Affect felt when exercising in nature does not only have a value on its' own, but may also motivate future exercise. In laboratory settings, affective responses during exercise have predicted future exercise behaviour (Williams et al., 2008) also when controlling for previous exercise behaviour (Kwan & Bryan, 2010). In natural settings, the positive affective responses associated with activity are also associated with greater exercise intentions (Thompson Coon et al., 2011). Behavioural intention is a crucial precursor of behaviour (see for example (Fishbein, 1980)). Effects on intentions have therefore strong implications for actual future behaviour. In this pilot study, we the effect of PAnat on intention to exercise in future was somehow controversial, as in fact a statistical significance was achieved only when adjusting the post-exercise ratings of intention for individual PA ratings (LTEQ). In the follow-up, significant changes of implicit attitude towards PA were not found, while only marginally significant differences in post-intervention PA ratings (and only for specific PA, i.e. 'biking in natural

settings' and 'exercising with rubber bands') where found. Furthermore the reliability of the follow-up outputs is hampered by a sensitive drop-out. Therefore, further studies are yet needed.
An interesting perspective arisen from this study, which deserves further attention, was the association between individual feelings of connectedness to nature and different parameters of PA, such as ratings of LTEQ, actigraphy outputs and scores at the IAT. Connectedness to nature could be an individual disposition and a relevant motivational factor that elicit PA, as the love for nature lead the individuals to seek for opportunities to be in natural environment and, likely, engaging in PA such as walking, hiking or gardening.

Research question 2: *Does PAnat promote restoration from mental fatigue and stress, improving the profile of biomarkers of psycho-physiological stress?*

It was found that, compared to the PAind, the subjects who participated in the PAnat (both, in the assessment study and the actual intervention study) reported assigned to the exercise-setting better restorative qualities of the environment, with higher ratings of *Fascination* and *Being Away*. These outputs confirm existing literature reporting greater perceived restorativeness of the environment in connection with PA experiences (Hartig et al., 1991; Hug, Hartig, Hansmann, Seeland, & Hornung, 2009). Anyway, this study represents a novelty because the intervention consisted in a complex exercise program of moderate-to-vigorous PA (MVPA), including activities which require a major performance-focus.
Although in this study, the effects of being exposed to restorative environments on cognitive performance were not directly tested, in previous studies it was found that greater perceived restorativeness of the environment in connection with PA experiences was associated with restoration from mental stress and enhanced cognitive performances (Hartig et al., 1991). A significant effect of the PAnat intervention on 'Fatigue' (component of PAAS) was not found. Anyway, it was found that Fatigue was negatively associated with Positive Affect, which on turn was found to be positively impacted by the PAnat intervention. On the other hand, the items compounding the affective component Fatigue in the PAAS may have been interpreted by the subjects as 'physical fatigue' rather than 'mental fatigue'. In fact, ratings of fatigue were found to correlate with ratings of RPE reported during the exercise sessions.
It was found that the PAnat group showed improvements of the profile of different indicators of psycho-physiological stress, especially cortisol awakening response and diastolic blood pressure. Positive affect has been previously associated with improved profile of cortisol profile and cardiovascular parameters (Dockray & Steptoe, 2010). It has been also found previously that exposure to natural environment while engaging in moderate PA (i.e. walking) was associated with reduced production of stress hormones and improved profile of indicators of autonomic cardiac control (Bowler et al., 2010). However, in our best knowledge, this is the first study showing positive effects of a complex exercise program of MVPA on indicators of psychophysiological stress. And most importantly, this is the first study in our knowledge showing medium-long term effects on parameters of stress tightly linked to reduced risk for poor physical health.

Research question 3: *Does exercising outdoors, exposed to natural daylight, increase the melatonin (MLT) production, improving the stability of the circadian structure?*

In our pilot study, an effect of the exercise intervention on the subjects' nocturnal MLT production or sleep-wake patterns were not found. Anyway, further analysis might highlight a relationship between the individuals´ MLT production and sleep-wake patters, exposure to light and PA behaviours.

Research question 4: *Does exercising outdoors, exposed to sunlight, contribute to higher systemic levels of vitamin D?*

In our pilot study, an effect of the exercise intervention on the subjects' vit-D levels was not found. Anyway, further analysis might highlight a relationship between the individuals´ vit-D status, exposure to light and PA behaviours.

Limitations and strength of the pilot study

The fact that the subjects knew to which group they were assigned could have reduced our possibility to highlight PRE vs. POST exercise changes of affect. Positive Affect in the PAnat group was increased, as compared to baseline levels, already before undertaking the exercise session. The 'expectation-effect' could be avoided by not communicating which exercise session a subject is going to undertake until the very last. In our study, though, this was not possible because of reasons connected with the participants' safety and the nature of the design. Furthermore, as a pilot study, the experimentation included only two experimental conditions, which represented the two extremes on a range of possible environmental settings. Future studies should include 'mixed-environments', such as indoors setting with presence of nature (e.g. plotted plants and videos or views on natural landscapes) or outdoor environments with no visual access to nature (e.g. urban settings). At this stage it is not clear if the positive effects of the PAnat setting on affect and Enjoyment were due only to the presence of nature itself, or rather to other elements, such as the natural daylight, fresh air, or more variety in the scenario. The novelty of exercising in a pleasant environment providing more variation of scenario is likely to have a major impact on the subjects' Enjoyment; yet it seems that the perceived restorativeness of the environment (Fascination and Being Away) was the most relevant variable explaining the higher Positive Affective response in the outdoor group.

A major strength of the study is its design, including within- and between-subjects effects, and the high quality of control upon environmental conditions and exercise outputs. The preliminary measurements allowed controlling for possible confounders and adjusting the post-exercise outputs for the individuals' baseline. The exercise sessions were performed at same time of day, avoiding possible influences due to circadian fluctuations of responses to exercise (Atkinson, Edwards, Reilly, & Waterhouse, 2007). Moreover, previous studies have only used single and rather short episodes of activity in their interventions (Thompson Coon et al., 2011). Our intervention used two episodes of instructed activity in addition to two follow up measurements of self-reported activity. Thompson Coon and colleagues (2011) further note that weaknesses with previous studies are sparsely reported eligibility criteria and baseline characteristics, and no description of the randomization process. We had clear inclusion criteria, and although the samples were small, they were stratified on the basis of age gender and activity level. In addition, ad hoc analyses revealed that the two groups were well balanced on any other demographical variable, or baseline measures.

A big challenge of this study was to reproduce fairly even conditions in indoor and outdoor settings. Other studies have previously studied the effects of exercising indoor (on a treadmill) vs. outdoor settings (Dasilva et al., 2011; Focht, 2009; Harte & Eifert, 1995; Kerr et al., 2006). In our study, we carefully studied the impact of the different environments on the physical exertion, also through a preliminary assessment study (cross-over design). While PA such as walking and cycling on static machines vs. over-ground surely implies different muscular interventions, we can assume that the strength bout (exercising with rubber bands) was reproducible in the two exercise-environments with no significant effects in terms of muscular intervention. Another novelty (an strength) of our design consist in the type of PA proposed, as in fact basically all the previous studies based on 'walking' or, fewer, 'running', which allow the practitioner to have an 'easy' focus of attention on environmental components. Especially, walking at a moderate pace, might sensibly limit the actual exercise-related effects on affective states, while mainly highlighting the nature-related effects. On the contrary, the PA proposed in this project was a complex and complete (including aerobic and strength components) exercise program of moderate-to-vigorous intensity, which required higher focus on the PA tasks themselves. Therefore, this study significantly extends further the knowledge about positive effects of exposure to nature while exercising.

Conclusion

Experiences of PA in contact with nature might enhance individual motivation to embrace active lifestyles. Engaging in PA in natural environment is a valuable opportunity to being exposed to restorative environments. Revitalizing and stress-relieving effects of PAnat can lead to improvement of profiles of psycho-biological markers of health and impact people's physical health in the long term. Furthermore, being physically active in outdoor setting might enhance people's vitamin D status and nocturnal MLT production, strengthening protective mechanisms and reducing the risk for chronic diseases. Anyway, further studies are needed.

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