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# Natural Science: A Human Practice

## - Expanding the horizon of established practice

Thomas Dillern

THE FACULTY OF EDUCATION AND ARTS

NORD University

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Finally, to my closest family, especially my mother and father, my elder sister and her family, my younger sister and lastly the girls at home - my girlfriend and the two greatest gifts of my life, my daughters Sofie and Maja: One of the things that the world known philosopher Martin Heidegger emphasized in his work was that every little existing thing in our universe is what it is in reference to its surrounding context, and that it is this contextual relation that makes the thing what it is. Thank you for being my main context.

**Abstract**

In this PhD-dissertation, I look at my own practice as a natural scientist. For several years I have conducted research within the sports and exercise discipline, published scientific papers concerning physical fitness related to soccer performance and related to the police occupation, as well as presented research on the subject matters at conferences worldwide. However, at one point, a feeling of not being able to account for choices and decisions made along the way occurred. With this came a creeping sense of doubt that perhaps some of the things that I have done in my practice have not been thoroughly thought out. That I, in a manner, have been on some kind of autopilot: as if decisions have been made for me rather than by me. This led to a desire to develop better understanding of my own scientific conduct. Hence, starting with questions like what I have done in my practice, how I have done it, and why I have done what I have done, I am drawn into some kind of reflection through my natural scientific conduct. As science largely consists of establishing new knowledge, my primary focus in the text is the process of knowledge development, addressing the deeper and fundamental ontological and epistemological issues concerning my practice. Nevertheless, this reflective journey is now manifested in this sort of comprehensive introduction in my dissertation.

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**Prologue**

Did you know that Leonardo Da Vinci used more than a decade to paint Mona Lisa? And, did you know that modern analyses have revealed the painting to consist of approximately 30 layers of paint? Recently it has also been speculated whether other women, or at least earlier versions of Mona Lisa, are hidden underneath the visible portrait. To me this emphasizes the tremendous scope of exertion behind this exceptional piece of art. For Da Vinci Mona Lisa represented a work in forever progress. A constant effort towards perfection: something serving as the ultimate definition of the things known as art (Dewey, 1934, p. 49). One of the features especially highlighted with the painting, perhaps the aspect where its true beauty is found, is the vivacity Da Vinci has brought forth in Mona Lisa's expression. However, this was by no means a coincidence; on the contrary, it was something Da Vinci truly endeavored to realize. In fact, at one point he wrote that accurately to portray the intentions of the human soul was one of his overarching artistic aims. To be able to do so he therefore studied human expression and human anatomy on a large scale: making observations and sketching those down. Based on this interest and his profound intellect, he over time developed a remarkable receptiveness, or understanding, of his observations and the surroundings he found himself in. To Dewey a true artist is found exactly in people holding such an unusual sensitivity to the qualities of things seen (Ibid, p. 51). Da Vinci's observing abilities as well as his abilities to grasp connections between what he saw thus stand out as especially determining elements of his geniality.

Everything Da Vinci observed and everything he thought about, were then systematically stored in some kind of mental arsenal – something as a parallel universe – a universe thereafter serving as the basis for the way it was possible for him to express himself through his painting (Jørgensen, 2008, pp. 38-39). In his endeavor for perfection, he thus created a projection in his mind – a vision of what the painting should be: a vision serving as the ultimate target towards which to aim his efforts. Da Vinci was hence not just a leading artist, but also a leading intellectual of the Italian Renaissance, something functioning as a figurative description of how aesthetic powers and intellectual powers merge to such an extent that their separation loses its meaning.

As we understand it then, the work with Mona Lisa did not consist of simply dipping the brush in the paint and then stroking the brush on a canvas. It all started with an interest, followed by thinking and observing and then thinking again. Da Vinci then perhaps did some painting before he again observed and thought about what he had done – as a continuous act of shaping and reshaping, shadowed by observations and critical thinking. If one part of the picture was changed, another part perhaps needed revision as well. The projection of what to come thus grew as the picture grew (Dewey, 1934, p. 51). Hence, every part of the work Da Vinci closely linked to the other parts and at each phase of the work, he was in a state of completing: constantly integrating what he was doing to what he previously had done, as well as with reference to the wholeness of what to come (Ibid, p.58). The projection in his mind therefore manifested in a desire for fulfilment, like an intense anticipating force (p. 57), where the different parts were in a common movement toward this fulfilment - a common movement towards an integral, completed, experience.

Furthermore, in Da Vinci´s desire to fulfil, we can also find an urge to express (p. 53). The projection he had when he was working was thus also public in its content, because he developed it in reference to the production of a completed work, accessible to the world (p. 53). When it comes to us, as the viewers or receivers of the finished painting, we however stand the risk of only being capable of considering it in its finished form. The scope of exertion behind it and the intimate relation between the practical acts accomplished and Da Vinci´s process of undergoing is not necessarily something we are capable of grasping. And, if we do not grasp this, it corresponds to no more than pure recognition, something that does not enable us to reach an understanding of the painting´s true meaning. This resembles a passivity where there is no possibility for perception because perception requires some form of responsive acts from the receivers (pp. 54, 56).

This pure recognition is, however, the very starting point in any act of understanding. When we attempt to understand something new, it always starts with the recognition of the preliminary meaning we have of the thing we attend to (Gadamer, 2003, pp. 36-37). To Gadamer (Ibid, pp. 36-37) this first meaning, though, only reveals itself because we already have some expectations of what the meaning will be. To come any further we have to penetrate deeper into it, and by doing this, new things will reveal themselves, making it necessary to revise the initial conception, we had of it. In fact, the process of understanding something is always a continuous revision of the preliminary understandings we already have of the thing we try to understand (pp. 36-37). Hence, we always are, or at least we

have the potential to be, in some kind of movement towards an expanded point of view.

Thus, if we want really to understand the true meaning of Mona Lisa, we need to create our own integral experience – something corresponding to a kind of re-creative act, where we in a manner go through the same operations as Da Vinci did (Dewey, 1934, p. 56). This is not an easy thing to accomplish, and to embark upon such a task is something many feel a kind of repugnance to. Dewey (Ibid, p. 54) describes how, when faced with something we feel difficult and which we feel a kind of resistance against, whatever it might be, we have two choices: we can continue to recognize, or we can begin to perceive. To Lindseth (2015, pp. 43-44) this corresponds to the choice between embarking on some form of easy un-reflected road or a more demanding and reflective one. The first does not seem to get us any further than we already are, the second, however, leads to the possibility of learning. The question now is which road do you take?[1]

[1] The prologue is based on Dewey´s descriptions of the work of an artist in the book *Art as Experience*. However, it is I who have placed Da Vinci in this context, and in this regard I have found support for his work from: http://www.biography.com/people/leonardo-da-vinci-40396

# I. The beginning – an unease

I have to begin with the very beginning. I was attending my first PhD course, and the first thing the professor did was to ask us students to write down, on a broadsheet, who we were as scientists or academics, which we thereafter were to present to the class. As I recall, I set out on the task, as did my fellow students, with great enthusiasm, describing my scientific accomplishments as well as my work experiences. Subsequently, one student after the other, with a little pride, presented their broadsheet to the rest: citing books, reports, and scientific papers and so on, as well as describing many years of work experiences. However, it struck me that the professor seemed to be anything but impressed. On the contrary, at least as I remember it, she looked a bit bemused. I am sure she gave some positive responses, but she had only one question to our presentations, directed to all the students, that really stuck with me: "What about your personal life; has it nothing to do with your professional life?"

Now I am sitting in my office thinking about this event. I have the lights in the ceiling switched off, the window blinds pulled down and the door closed. There is absolute silence: no disturbances, nothing that disrupts my attention. This is where and how I think the best, and now, something is changing. I am in motion. I am heading somewhere, yet, I do not know where. In one way, it feels as if I am quite close; in another, it feels so far away. It is chaotic, but it is a creative chaos. It is the feeling of being frustrated and despairing, but also excited and satisfied at the same time. Why did the words of the professor have such an impact on me, as though they hit something substantial? As if I suddenly realized something, yet something I am incapable of fully comprehending.

What I do know is that it has something to do with my conduct as a natural scientist. Over the last several years, I have carried out a number of studies, all within an exercise and sport domain and all within the scope of human physiology. Scientific papers have been published, and various works have been presented at numerous conferences worldwide. What is odd, though, is that if asked questions like what is the determining elements of my practice, what I can, what I know, why I have done the things I have done or even how I have become the scientist I am, I am in trouble. I am simply not up for the task. Do not get me wrong; it is not that I cannot come with some kind of answers to these questions. It is more like I am not fully conscious of what the answers are. As if, the words are on the tip of my tongue, but still too far away for me to express.

This unrest, or uncertainty, I believe, has been present for quite some time. The cause of these thoughts is not quite clear, but an initial indication was a realization of being unable explicitly to account for some of the choices and decisions I had made in my work. With this came a creeping sense of doubt that perhaps some of the things done along the way had not been thoroughly thought out. That, in a manner, I had been on some kind of autopilot: as if decisions had been made for me rather than by me. Another reason for these thoughts of doubt was a dawning realization that I had embarked on a scientific practice for which I was not formally qualified (I did not hold a PhD), and that this decision perhaps had been a bit premature. It was however a conscious decision: It was the feeling of standing at the airport gate when the plane was about to leave and the choice was either to board or be left behind. For me, it felt as if this was the only plane going; the discipline of sport and exercise sciences was not a high priority at the university and I believed this was my chance. Thus, I took the leap, and in the aftermath, I am not surprised that I did. I have always tried to become proficient at whatever I do, always tried to improve myself, and since the day I began an academic career, this obvious part

(doing research) of scientific work, was something I wanted to master. However, in retrospect, I wonder if I, in my haste, and given my lack of competence and experience, had overlooked something.

Apparently, hence, there are several associated elements contributing to these feelings of disharmony. I also think that they, at least to some extent, are connected to this PhD course where the meeting with this professor took place, and further that these thoughts have gradually increased as I have attended to consecutive courses. This creative chaos has hence grown stronger, like a storm approaching, and I cannot wait to immerse myself in it, before I fall behind, paralyzed and unable to act. According to Dewey (1934, pp. 36-59) these disturbing feelings of unrest can be a symptom of an unfinished experience. What I desire for is thus to finish it. Although this PhD pathway perhaps, in a way, is what has interrupted the experience, distracted me from my ordinary activities, it is perhaps also what has placed me at enough distance, so that my view becomes clearer.

## What to come then

The comprehensive introduction in this PhD thesis is an essay – an essay consisting of some kind of reflective journey through my own practice as a sport and exercise scientist. However, I have no predetermined direction in which this journey will go; I have no distinctive research questions or hypotheses to follow. On the contrary, my approach is rather open, and where it is, as described, this unease, this feeling of discrepancy and general wondering that sets some kind of approximate course. All I can hope for is more directional clarity to appear as I move forward. Consequently, as I know that I probably violate every expectation you might have on what a

comprehensive introduction to a PhD[2] should consist of, I thought it might be beneficial to your understanding and comprehension to provide you with some kind of reading guidance.

As you now probably have understood, it is my own natural scientific practice, deeply anchored within a modern natural knowledge and science tradition, which is the subject matter in this essay. The text consists of two narratives where I describe my own practice and the tradition within which I am standing. These narratives then serve as the basis for further reflection as they reinforce some of the initial indications, or issues, which have troubled me. Furthermore, the reflection itself is not something that happens within a vacuum: Although I am a sport and exercise scientist, I am currently also a PhD-student at a PhD-program rooted in the human sciences, and it is from this perspective that I now take a critical look upon my own practice. In this PhD-pathway, I have attended courses, read literature and participated in various discourses, and, to a large extent, it is in this context that questions concerning my sport and exercise scientific practice have arisen. Thus, alongside literature, I have thought about my own professional practice and I have attempted to develop, and to write forward, my own knowledge, my own personal point of view. Hence, in some kind of reflective process, I have worked with different issues, and this phenomenological-hermeneutical journey is now made manifest in this very essay.

As science largely consists of establishing new knowledge, the primary focus in the text is the process of knowledge development. It is however not mainly a methodical or result-oriented reflection: It is more as if the questions I have and the

[2] It is not a pure empiric article-based PhD, nor is it a pure monograph-based PhD –perhaps best described somewhere in between.

description of my research practice I accomplish, opens up the deeper fundamental issues that concern my practice. The journey will hence mostly move within an ontological and epistemological landscape, where I will address the underlying mechanisms within modern natural science: the fundamental assumptions, the rules of conduct, within my own professional practice. The ontological and epistemological topography in which this journey travels will perhaps, to some extent, make parts of the journey somewhat abstract. However, in every step of this endeavor it is my own scientific practice which I effort to address: it is about what, and why I have done the things, I have done, it is about what I know, what I believe and what I have learned and it is further an attempt to nuance the picture, to turn some stones, where both I and the tradition in which I am anchored have come to short. Subsequently, in relation to different PhD courses, I have written different texts, and these texts have now been further developed and put together in this comprehensive introduction. Even though I may have started out without any clear understanding to where this journey would go; my intention is, or at least my hope is, that the different parts of the essay in the end will prove to be complementary, and that they together constitute a meaningful whole. Furthermore, perhaps I, when resolving all these uncertainties, finally will be able to understand what the professor meant.

The question now is though, where to begin? As I utter this sentence aloud, however, the answer reveals itself instantly. To improve my understanding of my scientific conduct, I probably have no better choice than to begin by getting an overview of the scientific work that I have actually done. Hence, I have to start with the evident: a recapitulation of my published papers.

# II. The evident: A recapitulation of my published papers

Here six of my peer-reviewed scientific papers will be summarized:

1. Ingebrigtsen, Jørgen; **Dillern, Thomas**; Shalfawi, Shaher A. I. *Aerobic capacities and anthropometric characteristics of elite female soccer players*. Journal of Strength and Conditioning Research 2011; Volume 25(12) pp. 3352-3357
2. **Dillern, Thomas**; Ingebrigtsen, Jørgen; Shalfawi, Shaher A. I. *Aerobic capacity and anthropometric characteristics of female elite-recruit soccer players.* Serbian Journal of Sports Sciences. 2012; Volume 6(2) pp. 43-49
3. Shalfawi, Shaher A. I.; Ingebrigtsen, Jørgen; **Dillern, Thomas**; Tønnessen, Espen; Delp, Tor Kristoffer; Enoksen, Eystein. *The effect of 40 m repeated sprint training on physical performance in young elite male soccer players.* Serbian Journal of Sports Sciences. 2012; Volume 6(3) pp. 111-116
4. **Dillern, Thomas**; Jenssen, Ole Ragnar N.; Ingebrigtsen, Jørgen. *Physical fitness and anthropometric characteristics of graduating Norwegian Police University College students.* European Journal of Policing Studies 2014; Volume 1(3) pp. 192-205
5. **Dillern, Thomas**; Jenssen, Ole Ragnar N.; Lagestad, Pål; Nygård, Ørjan; Ingebrigtsen, Jørgen. *Arresting a Struggling Subject: Does the Forthcoming Police Officers' Physical Fitness have an Impact on the Outcome?* The Open Sports Sciences Journal 2014; Volume 7. pp. 2-7
6. Lagestad, Pål; Jenssen, Ole Ragnar N.; **Dillern, Thomas**. *Changes in police officers' physical performance after 16 years of work*. International Journal of Police Science and Management 2014; Volume 16(4) pp. 308-317

One may divide these six studies into two categories, according to the different groups assessed: physical fitness in relation to soccer and physical fitness in relation to the police occupation. In this recapitulation, I will present the studies in the same order. Due to the considerable amount of data, I will mainly emphasize the studies´ primary purpose in this recapitulation.

## Physical Fitness in Soccer

### Introduction

At the time of the three first studies, I was working in the university´s exercise and sport-testing laboratory, among other things measuring soccer players' aerobic endurance performance ability. The general aim of this testing was to monitor athletic development and to examine the effect of different training and competitive periods on physical capacities. Physiological capacities are important

factors in elite soccer performance (Metaxas et al., 2005). In terms of endurance, a soccer match consists mainly of intermittent activity. There are short periods of maximal or submaximal intensity and longer periods of low intensity (Miller et al., 2007). A soccer match's duration is between 90 and 120 minutes, and during a game, the players are faced with diverse physical demands, which all call for efficient energy delivery (Mohr et al., 2005). Most of the match is played with low to moderate intensity, which means that the soccer game is mainly covered by the aerobic energy-delivery system (Bangsbo, 1994, Ekblom, 1986). When even recovery between periods of high intensity depends primarily on aerobic metabolism, this system is emphasized as particularly important in soccer (Bangsbo, 1994, Billaut and Bishop, 2009). Furthermore, soccer players' aerobic capacity has also been shown to be competition-level dependent, implying that measurements of maximal oxygen consumption could be a criterion for identifying a successful player or team (Svensson and Drust, 2005). Hence, from both a scientific and a practical perspective, knowledge of what is required of the top-level player, as well as how these capacities develop toward the elite level, is of great interest.

As a part of my work in the laboratory, I also functioned as a kind of physical trainer for the players individually, as well as the team as a whole. Based on the test results, individual training programs were developed for the players and general advice was given in regard to how to achieve optimal effect in their training process. There was also close dialogue with the team's coaching staff, with the aim of designing the best possible structure and periodization for the training in general. Within this discourse one question often raised by both players and coaches, especially from those particularly interested, was, what should it be? By this they meant what should their ideal test score be, or put in a different way, how were the results compared with national and international standards? In regards to athletes from many different sport disciplines, it was quite easy to give appropriate answers when these

questions occurred. Published data were often available in diverse fora. However, when it came to female soccer players, I was unable to answer these questions with anything more than some kind of informed guesswork. There were plenty of data on the male soccer player to use as reference, but not much on the female player. My inability to give adequate responses to these questions bothered me. To meet players and coaches as a kind of exercise expert unable to give more than approximate answers felt frustrating. Furthermore, the lack of an ability to give adequate responses was not the only thing troubling me. Being deeply interested in soccer physiology, this was something I really felt a desire to find out, and ultimately this led to the idea to try to fill this knowledge gap. Hence, the purpose of the first study was to establish normative and objective data on female elite soccer players' aerobic capacity characteristics.

The second study must be understood as an extension of the first. In the laboratory there were not only elite players coming for testing. There were also recruits, and just as for the elite groups, it was of interest to compare the recruits' physical performances with national and international standards. However, what seemed even more important to consider for these groups was their development toward elite performance. Here again data for comparison were scarce, which led to a study aimed to detect aerobic endurance capacity in recruit female soccer players in order to establish developmental stages (standards) towards elite-female soccer performance.

Consequently, the main purpose of the two first studies was to identify and establish aerobic capacities for Norwegian female elite, and female elite-recruit, soccer players. Furthermore, as previous research had shown that aerobic performance within a soccer game, as well as the players' aerobic capacity, differed according to their playing position on the team (Bloomfield et al., 2005), a second

aim was to examine whether there were systematic differences in these capacities between players in different positions.

The two first studies aimed to establish descriptive data on female soccer players' physical capacities. Another question that arose within this soccer physiology discourse, among players and coaches and in my collegium, was how to improve these capacities in the most effective manner. We were interested in knowing what type of training would have the best effect on soccer players' aerobic capacity. As mentioned above, a soccer match consists of long periods with low to moderate intensity combined with short periods of high to maximal intensity. In fact, one of the most important physical capacities specific to soccer performance is repeated-sprint (high to maximal intensity) ability, and these actions have been described as the crucial moments of a soccer match (Reilly et al., 2000). Research has also shown that top-level teams have the ability to perform and repeat these actions more frequently than lower-level teams (Iaia et al., 2009). Yet, when exploring the literature we found very few attempts to examine how these high-speed actions were influenced by training, and none whatsoever in regard to isolated repeated-sprint training. Hence, when I was invited to participate in a study to examine the effect of a physical training intervention on the different physical capacities of male elite junior soccer players, I did not hesitate. The main purpose of this study was to investigate the effect of an eight-week, specialized, repeated-sprint training program on elite junior soccer players' repeated-sprint ability.

**Methods**

In the two first studies, the same cross-sectional design was applied. The tests were conducted during the preseason period. The elite team was preparing for competition at the highest national level and the recruit team, at the third senior level. To identify and establish aerobic capacities we tested the players' anaerobic

threshold (AT) and maximal oxygen consumption (VO2max) with treadmill tests in the laboratory. Standardized and reliable equipment and procedures were used in both tests. The test protocol designed to test AT consisted of 5-7 increases in speed of 1 km/h every fifth minute. Before every speed elevation, the protocol was stopped for 30 seconds, allowing for the collecting of blood lactate from a finger prick. After the first test, the players received a short break before the VO2max test commenced. This test involved a continuous incremental protocol, with load increases every 30 seconds for a total duration of 5-6 minutes.

For each variable, descriptive statistic was calculated and reported as mean and standard deviation of the mean for the team as a whole and for each group of players. The differences in physical characteristics between the groups were analyzed using a one-way ANOVA followed by a Tukey post-hoc test or a Kruskal-Wallis test, followed by the Mann-Whitney test.

In the third study, a pre-/post-test experimental design was used. The training intervention was applied in the preseason period. At the time, the team was among the four best teams in the country in its specific age class. The repeated-sprint test consisted of 10x40 meter maximum sprints with 60 seconds of recovery between each sprint and completed on artificial grass in an indoor soccer stadium. All players performed the pretest and then randomly joined either a training group or a control group. The control group continued the team's original training plan whereas the training group completed two extra repeated-sprint training sessions weekly. The sprinting session included four sets of 5x40 meters with 90 seconds of recovery between repetitions and 10 minutes of recovery between sets, as well as both a general and a specific warm-up in advance. After eight weeks, the post-test was conducted for both groups. To assess differences in variables between the pre- and

post-tests a paired sample t-test and an independent sample t-test were conducted. The results were expressed as means and standard deviations.

**Results and discussion**

In the first study, we measured several variables, all related to aerobic capacity, and these results provide normative physiological data for elite female soccer players. Most of the variables we examined had not previously been reported. However, some had, and in general, our results were comparable to these findings (Davis and Brewer, 1992, Evangelista et al., 1992, Helgerud et al., 1999, Jensen and Larsson, 1993, Rhodes and Mosher, 1992, Tumilty, 1993). The most important variable we measured was the players' maximal oxygen consumption, and we found average results in the different positional groups to vary between 50.7 and 55.3 ($mlxkg^{-1}xmin^{-1}$). In the second study, we established the same normative data as in the first study, but this time for a group of elite-recruit female soccer players. The specific results for this group were found to vary from 48.7 to 53.8 for different positional groups ($mlxkg^{-1}xmin^{-1}$). Although this study found the recruits to perform worse than the elite group, they also, in general, performed better than reported in previous research (Davis and Brewer, 1992, Evangelista et al., 1992, Helgerud et al., 1999, Jensen and Larsson, 1993, Rhodes and Mosher, 1992, Tumilty, 1993).

However, in both studies we found very few differences between the different playing positions. The only significant differences we detected in both studies were related to the goalkeepers compared to the other groups. As previous research has revealed several positional differences among soccer players with respect to physiological variables (e.g., (Bradley et al., 2009, Pena Reyes, 1994, in Williams & Reilly, 2000), these findings were rather unexpected. A possible, although speculative, explanation could be the timing of the tests, which were conducted during the off-season, and hence when the players had limited specific match

training. Alternatively, the results might reveal a lack of individualization of training in light of the different physical demands placed on different playing positions (Vescovi et al., 2006).

Furthermore, as these two studies go back a bit in time it would be interesting to compare them with studies that are more recent. In an update-study from 2014, Datson et al. reviewed the literature concerning the physiology of female soccer players. In regards to maximal oxygen consumption, our study of elite players from 2011 was the most recently published study included in this update. Thus, it did not reveal any data, which was not accessible to us back in 2011. However, a review, also from 2014 by Martìnes-Lagunas, Niessen and Hartmann, included three new, although one un-published, studies concerning physical fitness related to female soccer performance. When comparing the results reported in two of these studies with our results they proved to be quite comparable with reported maximal oxygen consumption being 52.7 – 54.6 ($mlxkg^{-1}xmin^{-1}$) (Martìnes-Lagunas et al., 2013) and 53.9 ($mlxkg^{-1}xmin^{-1}$) (Sjökvist et al., 2011), respectively. In the third study, on the other hand, by Green et al. (2013), it was disclosed substantially lower level of aerobic fitness compared to our results with an average maximal oxygen consumption of 44.2 ($mlxkg^{-1}xmin^{-1}$). This low level may be explained by the fact that the participating females in this study were lower level (collegiate) soccer players.

It is interestingly, though, that the review by Martìnes-Lagunas, Niessen and Hartmann (2014) elaborated on the problem concerning lack of positional differences observed in physical fitness in female soccer. They emphasized that the physical demands placed upon players in central and external positions, both in defense and midfield, during match play are too different to be placed in the same category, as among other studies, our had done. Consequently, they appealed for a

more detailed classification in future work, hoping that this could lead to studies not missing actual differences.

In the third study, the results revealed that the training group improved their repeated-sprint ability significantly more from pre- to post-test, compared to the control group ($p < 0.01$). This shows that repeated-sprint ability is trainable and confirms, for the first time, that specialized repeated-sprint training alone influences this ability positively. However, when exploring the development of the training and control groups from pre- to post-test separately, a significant improvement within the control group was also found. A plausible explanation for this is difficult to determine, but it could be due to the timing of the study, which was preseason, when enhancing physical performance in general is a substantial training focus (Svensson and Drust, 2005).

**Conclusions and practical implications of the first, second and third study**

Aerobic capacity is an important physiological factor behind soccer performance, and the first two studies included in this PhD thesis aimed primarily to identify and establish this capacity of Norwegian female elite, and female recruit, soccer players. Within a multifactorial perspective upon elite soccer performance, and as well in regards to athletic development toward elite soccer performance, it seems beneficial to take into account some objective measures of capacity standards and developmental stages. However, we find our results, showing very few differences in capacity between playing positions on both teams, disturbing. These findings may highlight the need for optimized training tailored for the mastery of the different positional demands within female elite soccer.

On the contrary, the lack of any difference in physical fitness between the different playing positions, as emphasized above, may also be explained by methodical

limitations. Adding more categories, dividing between external and internal roles in both the midfield and defense, might make it possible to detect real differences in physical abilities between the different positions on the team. This reveals a particular issue concerning this kind of research: having more categories can seriously jeopardize the process of achieving large enough sample sizes to carry out advanced statistical analyses. To get elite athletes to participate in research, and perhaps especially in exhausting and time-consuming laboratory experiments, is not easily accomplished. In addition, these elite athletes are often coming from rather small populations. For that reason it also exist some kind of distinction between the theoretical population and the actual available population, since the research is anchored in a geographically locked laboratory. Hence, adding two categories to the variable could make such studies almost impossible to carry out in practice. In my opinion, we have to have in mind the ideal approach, but still attempt to do what we can within the frames available.

Nevertheless, having such small samples, as one often see in this kind of research, and as present in these two studies, limits both the data's statistical and external validity. Again, in my opinion, this does not have to imply that the data gathered and analyzed cannot have any scientific and practical implications of interest. In our defense, we also did a quality check on the data prior to any inferential statistics by tests of normality and variance, and where we subsequently, in any case where these assumptions were violated, conducted non-parametric inferential statistics instead of parametric. Another consideration in our favor concerning our small samples was the expected low variability in measurements because of the general high precision present in objective laboratory testing. Anyhow, through these two studies we have gained a better understanding of the elite, and elite-recruit, female soccer player, and consequently some of the factors that determine female soccer performance in general.

In the third study, we showed repeated-sprint ability of young soccer players to be positively affected by a training intervention. The volume of the intervention was, however, at a rather low level, so it would be interesting to examine in a future study whether a stronger stimulus, on a group of higher-level performers, would result in further improvements. Nonetheless, in the two first studies, we detected some of the factors that constitute the physical performance of soccer players, and in the third study, we showed how this physical performance could be improved by implementing an effective training stimulus.

## Physical Fitness in the Police

### Introduction

The fourth, fifth and sixth studies concern measurements of physical characteristics related to the police profession as well as police education. At this point, I had begun teaching, among other courses, physical training at the Norwegian Police University College. I immediately understood that there was a common opinion among my new colleagues, students and police practitioners that physical training and the maintenance of some level of physical fitness were crucial in order to perform the police job satisfactorily. Something that also is important in regards to my entrance into this police context is that I brought along some kind of fitness perspective that also included a health focus. This was because I, in advance, when still located in the exercise-physiology laboratory, had taken a course in public health, making me interested in physical exercise and physical capacity, not only in relation to the development of athletic performance, but also in relation to a general health perspective. The choice of attending this course was because it was not solely sport athletes that were coming to the laboratory for various tests of physical capacity. Recreational athletes were also occasionally coming. Similar as the sport athletes, they were interested in determining their physical fitness according

to some general standards related to factors such as age and gender. Again, this feeling of frustration due to not being able to give adequate answers arose. On a general basis, I could give advice, yet I was not satisfied with the knowledge base I relied on for my answers. In regards to fitness among the general Norwegian population no standards existed and I became interest in exploring this subject matter more closely. This general interest further led me to conduct a large study - KAN-study – (Dillern, 2012), collecting a comprehensive amount of normative data concerning physical activity, physical health and physical fitness characteristics of a representative sample of the adult population in Nordland County, Norway. Thus, when I later approached physical fitness in relation to the police occupation this health focus was something I brought along.

Nevertheless, although some level of fitness was determined as important for being able to cope with the occupational demands of policing, the knowledge base for this opinion, and even more importantly, for the mandatory course and examination at the University College, and furthermore for potential demands placed upon the operative workforce, was rather insufficient. There was no documentation concerning how physically demanding the Norwegian police occupation was, what physical characteristics (strength, agility, endurance, etc.) a police officer had to possess, and to what levels, they had to be developed. In my opinion, the foundation for the whole course was lacking, and, in a certain sense, I found it difficult to meet the students with the trustworthiness and professional integrity that I wanted. Some data existed internationally, but these were rather sporadic, inadequate and not placed in relation to the Norwegian context. The more I thought and read about the subject matter, the more I wanted to understand it, and my intention with these studies was thus to begin the work of establishing these normative data, to start the work of enhancing my own understanding.

A review by Bonneau and Brown (1995) identified the physical demands police officers most often had to perform, namely running, jumping, crawling, balancing, vaulting, climbing, lifting, carrying, pushing, pulling, fighting and dragging. Demands such as these have to be encountered with a high level of general physical fitness among the operative officers. Their importance becomes especially apparent when considering that they occur frequently and that they can be stressful, even life threatening for both the officer and the surrounding civilians (Bonneau and Brown, 1995, Boyce et al., 2009). However, physical fitness is not only of significance in terms of the more extreme part of the job. Many police tasks of a more ordinary character require some level of physical fitness, and one therefore considers it as a prerequisite to being able to perform the profession in a satisfying manner. This is also the rationale for physical fitness tests being included in the admission requirements at the Norwegian Police University College, as well as the aforementioned mandatory course and examination in regards to physical education and training. Hence, one could claim that physical fitness is highly emphasized at the college. Yet this emphasis ends when the students graduate and become part of the operative police corps. Norwegian police authorities have no physical requirements for the operational force and do not monitor the force's physical standard and development. Whether or not officers possess the necessary fitness to perform their job throughout their careers is therefore an unanswered question. An age-related decrease in fitness level observed in the police in a previous study heightens this concern (Bonneau, 1987, Burelle et al., 1987).

In our complex contemporary society, the police face challenges that, to be met adequately, to a high degree require characteristics and qualities other than physical fitness. Consequently, the working day of a police officer is not necessarily very physically demanding. Most of the tasks involve low-intensity work or even physical inactivity (Sörensen et al., 2000). For this reason, the occupation is also revealed as

lacking the physical demands that would otherwise have a positive impact on physical fitness (Bonneau, 1987, Burelle et al., 1987, Smolander et al., 1984), and police officers who do not participate in sufficient leisure-time physical activity therefore have trouble maintaining their fitness level (Stamford et al., 1978). However, even if the majority of work can be executed independently of the officer's physical fitness, many tasks still demand a certain level of physical fitness, and if the officer is not capable of managing these tasks as well, his or her capacity to do the job at all, may be questioned. We therefore wanted to establish a knowledge base concerning Norwegian police officers' physical fitness characteristics, beginning with the starting point of the police career. Hence, the main purpose of the fourth study was to establish the physical fitness characteristics of graduating students at the Norwegian Police University College.

To what extent these general fitness characteristics were transferable to more police-specific physical tasks was a question that arose, following the fourth study. Therefore, it became of interest to explore whether police officers' general physical fitness affected their ability to cope with a highly occupation-specific task of physical exertion. In the everyday police job, the officer can meet, as mentioned, a variety of physical demands. One of the most critical and stressful physical tasks of operative police work is gaining control over a struggling suspect during an arrest (Bonneau and Brown, 1995, Sörensen et al., 2000). Even if the apprehension of a strongly intractable subject is not reported to occur frequently, it is described as the most commonly occurring maximal physical exertion in the profession (Sörensen et al., 2000). The main purpose of the fifth study, therefore, was to examine whether the police trainees' general physical fitness affected their ability to handle a struggling subject during an arrest-simulation test.

This initial phase of establishing a knowledge base of physical fitness in the police occupation, which focused on police trainees, was followed up with a study on physical performance in the force. The sixth study was designed to measure the physical fitness characteristics of active-duty police officers and to compare the results with those from the same tests, performed 16 years before, when the officers were at the beginning of their careers.

**Methods**

Procedures

In the fourth study, we used a cross-sectional study for detecting physical fitness characteristics at the starting point of the police career. Hence, 78 graduating students at the Police University College performed four physical fitness tests over two days. On the first day, a one-repetition maximum (1RM) bench-press test in a Smith machine, a strength endurance pull-up test and a test of explosive leg power, consisting of either a standing broad jump or a countermovement jump, were conducted. On the second day, a 3000-meter endurance test was performed on a standardized tartan track and field course, with 7.5 laps equal to 400 meters. The results were then reported as means, and independent sample t-tests were used to compare differences between genders.

To assess the relationship between general physical fitness and the ability to perform in a simulated arrest-handling situation, we used a descriptive correlative-explorative study design in the fifth study. Nineteen graduate students at the Police University College conducted the same four physical tests as in the fourth study (not the countermovement jump), and scores from the different tests were converted into a physical test index (physical index). Further, a test designed to simulate the handling of a struggling subject during arrest was conducted. The simulation contained two takedown tests and two self-defense tests and was developed to

assess Norwegian police students' and active-duty officers' ability to apprehend and restrain a resistant subject during an arrest encounter. Scores from the four different tests from the arrest simulation were also converted into a performance score index (arrest index), which then was correlated (Pearsons' product moment correlation coefficient) with the physical index.

In the sixth study we aimed to examine Norwegian on-duty police officers' physical fitness 16 years into their career and then to compare the results with retrospective data from when the officers graduated. In 1995 the same four fitness tests as those used in the fourth and fifth study were used (bench press, pull-ups, standing broad jump and 3000-meter running), and in order to assess development from pretest to post-test, the same tests and methods were applied in 2011. However, out of the 200 individuals who had graduated in 1995 and were still working as police officers in 2011, only 55 agreed to participate in the follow-up testing. Nonetheless, to assess the data we used a paired sample t-test.

**Results and discussions**

With the fourth study, our main aim was to establish physical fitness characteristics of graduating police students from the Norwegian Police University College. Tests of strength, explosive power and endurance were conducted and the results revealed the upcoming Norwegian police officers to perform well compared to relevant reference groups. Few studies for comparison existed. However, when comparing the test results to the achievements of other groups, we found that the police students performed better than American police recruits (Boyce et al., 2009), American military personnel (Harman et al., 2008, Kraemer et al., 2001), Finnish police recruits (Sörensen et al., 2000), Norwegian military recruits (Dyrstad et al., 2006) and Italian firefighter cadets (Perroni et al., 2008). Additionally, the females

outperformed female American active-duty police officers, whereas the males scored similarly to the same group of American males (Boyce et al., 2008).

In the fifth study, we mainly examined whether the forthcoming police officers' general physical fitness affected their ability to handle a struggling subject during an arrest-simulation test. The results showed a strong relationship; however, the causality was not further examined. Yet we interpret the results to indicate that some level of physical fitness increases the ability to handle an intractable subject during an arrest encounter, as was also found previously by Willmore and Davis (1979) and Greenberg and Berger (1983). That this relationship exists is not surprising, as, according to Anderson et al. (2001), an intractable subject in such situations will attempt to avoid the officer's effort to gain control over him or her, often by using physical force such as pushing and pulling the officer. This forces the officer to counterattack by applying the same methods, and Anderson and his colleagues revealed that officers in 93% of all such incidents had to push and pull the subject in order to gain control. The muscle activity when pushing and pulling corresponds to the muscle activity carried out during bench press and pull-ups, which may explain the relationship between the two indexes, at least to some extent.

The main purpose of the sixth study was to examine police officers' physical performance over time in the same four physical tests as used in the fourth and fifth studies. Specifically, police officers' levels of physical performance at graduation were compared with their levels of physical performance after 16 years in service, and results revealed performance in the four tests to have decreased 10–32% from pre- to post-test. Similar findings were also found in the Finnish longitudinal study from 2000 (Sörensen et al.). However, the American study from 2009 (Boyce et al.) revealed contradictory findings. Methodological disparities as well as other

underlying factors such as bodyweight, make comparing the three studies somewhat difficult. Nevertheless, as the level of physical activity in the Norwegian police corps is shown to decrease with increased years in the service (Lagestad and Tillaar, 2014), the present results, which show physical fitness to substantially decrease after 16 years in the occupation, are worrying.

A general finding in all these three police studies was the gender difference in physical fitness, with male participants consistently performing better than females. When we know that the demands of the occupation a given situation calls for, do not distinguish between who the officer at the scene is, and what physical resources he or she has to solve the potential problem, these results may be somewhat troubling. A failure in meeting the physical demands of the occupation can lead to less problem-solving efficiency and it can endanger the situation for the actual officer, his or her colleagues and the general public. It can also cause increased injury frequency and disability that may lead to increased sickness absence in the force.

**Conclusions and practical implications of the fourth, fifth and sixth study**

With these three studies, we have begun the work of establishing a knowledge base on physical fitness in the Norwegian police occupation. Until the present time, knowledge of this subject did not exist, and these studies therefore provide a better understanding of some of the characteristics that the police possess. We have also shown that attributes of general physical fitness are transferable to highly occupational-specific tasks of physical exertion, which again highlights the importance of the results. Furthermore, we disclose that present graduating students from the Norwegian Police University College to outperform several comparable groups in the level of physical fitness. Hence, we have shown that they seemingly are fit enough to cope with their upcoming job. This, however, does not

invalidate that there is a challenge in the Norwegian police corps in regards to decreasing physical activity and physical fitness with increased years in service.

Furthermore, the general finding that females scored lower than their male colleagues is an issue that requires attention in regards to both police education and training, and with respect to management of human resources in the police related to specific assignments and the more general composition of available crew. Although we cannot expect females to perform equally physically with males, on a general basis, we need to assure that each individual accepted into the occupation at least uphold minimal standards. We need a police corps that is able to perform every aspect of the job independently of sex, age and years in service, and we believe our research emphasizes the need for more focus on this issue from police authorities. A program to monitor physical fitness and health, including annual testing, should be implemented to ensure that police officers are able to cope with the physical demands of the occupation. We hope such focus from the authorities will lead to higher motivation and interest among active-duty officers, which will in turn lead to higher levels of leisure-time physical activity.

## Some summarizing thoughts of this recapitulation

By this review, I have recapitulated six of my publications with the aim of enhancing understanding of my own scientific conduct. It is clear to me that many similarities exist, some of which perhaps can be described as especially determining elements of my practice. In general, the publications can be divided into two different categories, or two different groups (concerning soccer players and police officers), and this distinction does, to some extent, disclose a change in subject matters addressed and specific methods applied. However, in my opinion the similarities throughout my work are more prominent than the inequalities. I believe it is more

the surrounding context that changes rather than my professional practice, and that there exists some kind of continuation across, or symbiosis between, the two groups assessed. In relation to both research directions (as well as in relation to the KAN study) I found myself in the midst of human contexts. In these contexts, I faced unsatisfactory feelings of not being able to fully understand, or explain, something. Hence, in a manner it was my own curiosity, my eagerness to understand, and my own inability to find satisfaction in halfway answers, which ultimately led to the intentions to explore these subject matters more deeply.

One of the most common features of my practice is therefore how my intentions led me into the somewhat consistent scientific endeavor of mine. Even though the context, which I stand in the middle of, is changing, the way I scientifically approach these contextually occurring questions, going systematically to work to find the answers, to me discloses a major consistency in my work. It feels, and seems, as if what I have learned in one context is being utilized in the next. This personal development hence functions as an expanding basis, which new challenges are met with, and which potentially might develop new aspects of any subject matter that I address.

Although the change of context, at least partly, came because of my change of work place, it was thus not as if the old practice was left behind. It was not as if I just closed the door to it; on the contrary, in a manner, I took it with me. The main topics addressed in the police studies are physical fitness characteristics of the upcoming police officers, mainly in relation to operational performance demands of the occupation, but also within a health perspective. The emphasis on the performance-related fitness components, I believe developed when I was studying elite soccer players. The more health related emphasis, in relation to both everyday lifestyle and occupational life, had grown out of my work, studying physical activity and physical

fitness in the general population (both in general and related to the KAN study). Ultimately then, these two research emphases were synthesized when I moved into the policing context. The knowledge gained in my previous work formed the point of view with which I met this new context. The conception, with which I attempted to understand physical fitness in relation to the police occupation, was thus shaped in the physiology-laboratory environment and mindset.

Some inequalities are, of course, present in my work. A main aim in regards to both groups assessed was to establish physical fitness characteristics related either to some athletic or to some occupational demands the participants had to cope with. Yet, when I moved into the policing context, I became immediately aware of a great lack of knowledge supporting the educational program at the university, as well as the physical demands placed upon the forthcoming police officers. At least in a national context, the evidence was absent. This is though not to say that fitness related to female soccer, when we started working on this subject matter, had in advance been thoroughly scrutinized. It was however obvious that in the case of trying to understand female soccer players, we found great support in the more well-established, extensively elaborated, knowledge foundation concerning male elite soccer. Scientific studies addressing physical fitness, both health and operational performance related, associated with police work were on the other hand scarce. Actually, according to Bonneau and Brown (1995), the effort to give some kind of objective descriptions of physical/occupational fitness related to police work first occurred in the 1970-1980s. It is further obvious that this research focus has not achieved any great-scale interest, and presently the number of scientific studies which have explored this subject matter comprises no more than some dozens.

When it came to the policing studies we were thus somewhat concerned by the lack of an evidence-based framework for our work. This concern was apparent in regards to the determination of how to approach the subject matters, how to measure physical fitness in a police context, and in regards to the contextualization of the data, which the studies resulted in. Existing research did not reveal any consensus about what and how, to measure, and the choices made seemed to be somewhat arbitrary choices, both in terms of the tests applied, and the critical values, or standards, for these tests. Thus, we felt that the scientific foundation underpinning our own choices of tests, as well as the forming of a direction for the interpretation of the outcome they would give, was insufficient.

Further, what seemed as an even more important fragility in this deficient knowledge basis was that precise data on the actual physical demands police officers had to cope with during work was also lacking. Hence, we did not have solid data on police officers' actual physical profiles, and neither did we have any solid data on the physical activity profile of policing. However, the establishment of an activity profile, or task analysis, is emphasized as the most crucial part in the development of any test or standard (Ibid). Unless we understand the physical requirements placed upon the operational work force, our attempts to test the relevant physical characteristics of police officers will be less valuable.

If we again cast a glance at physical performance in soccer, it exist a quite extensive knowledge foundation, describing the activity profile of soccer match play. For example, by the use of multiple-camera analysis systems, global positional systems and heart rate monitoring devices (e.g. Bloomfield et al., 2007, Osgnach et al., 2010) it has been possible to continuously observe and describe thoroughly the activity demands of soccer, without interfering with normal game-play. These data have also been supplemented with various tests and measurements before and after

match play (e.g. blood samples, muscle biopsies and sprint, repeated-sprint, and strength tests, e.g. Krustrup et al., 2004, Krustrup et al., 2006), which have further enhanced our understanding of the activity profile of soccer. Based on this well-established knowledge, it has thereafter been possible to determine relevant tests to assess players' physical profiles.

Hence, my professional practice in relation to my work with soccer performance had a more developed conceptual and methodical consensus, in which I could find support, compared to the work with police performance. In a way it feels now as if some essential parts of this knowledge-developing process was overlooked, that this necessary frame within the police context, these points of reference, went by me somewhat unnoticed. Consequently, as I now, still, find myself within this police context it is obvious to me that the establishment of these points of reference constitutes some kind of natural step in the continuation and further development of my professional practice.

This is though not to say that such explorations have not been undertaken previously. Mostly, however, these attempts have occurred from, and within, a pure police context, initiated and executed by police departments and/or police authorities. There are, however, a few scientifically published studies aimed at describing the physical demands of policing. One of those is the previously mentioned review-study by Bonneau and Brown (1995). This study, among other things, describe the most frequently occurring physical tasks police officers need to cope with, and the authors come to some kind of conclusion that police work demands the ability to perform the core of physical tasks. In fact, this paper has functioned as some kind of reference paper that different scientists addressing this subject matter have found support in. However, one can raise questions regarding the scientific quality of the data, upon which Bonneau and Brown are founding their

descriptions. The task analyses were mainly carried out by police departments or police authorities; accordingly, they have not led to scientific publications, easily accessible to the scientific community. The specific data they have included in their review, as well as the methods applied to gain these data, is thus not easily thoroughly verified in retrospect. Another point is that the authors base their inferences mainly on self-reported data and/or interviews and not on actual measurements of exact activities performed.

In a more recently published paper by Anderson, Plescas and Segger (2001), actual measurements of the physical occupational tasks with which police officers had to cope was however reported. In this study, 121 police officers were observed during their regular work-shifts and the different activities they conducted were recorded on a “minute by minute basis”. The scientists recorded how often, or for how long, officers performed certain activities - activities reported in advance as important, and frequently occurring activities by the officers themselves. The observations showed that the activities the officers mostly had to cope with was (with average minutes per shift) standing (138), walking (94), bent over at waist (14), lifting and carrying below shoulder (9), pulling and pushing (7), squatting/kneeling (7), running (3) and lifting and carrying above shoulders (1) (Ibid). Alongside the observed activities, the officers involved self-reported perceived effort. In this relation, the officers reported activities such as running, pulling and pushing, dragging, lifting and carrying and leaping and jumping, as demanding medium to maximum effort (Ibid).

Even though there are few studies aiming to give some kind of activity profile of the physical performance in regards to policing, both studies (as well as the others previously mentioned) provide valuable descriptions of the physically demanding occupation. What is also interesting is that both studies reach, although without invalidating general fitness tests, some kind of conclusion that for assessing

individual police officers' physical abilities, comprehensive occupational tests are preferable. Hence, they attempt to develop wide-ranging simulation tests reflecting the exact performance in real-life situations as much as possible. This emphasis has led to the development of several tests, such as POPAT (Police Officer Physical Ability Test), TAPE (Test d`Apitude Physique Essentielle) and PARE (Physical Abilities Requirement Evaluation) (Anderson, Plescas and Segger, 2001, Bonneau and Brown, 1995, Strating et al., 2010).

The authors' (Anderson, Plescas and Segger, 2001, Bonneau and Brown, 1995) main argument for designating occupational tests as superior to more general fitness tests is because they claim them to uphold higher construct-validity[3]. They are further nuancing this argument by pointing to problems with lawsuits, because of the implementation of general fitness tests in relation to employment recruitment. In a legislative manner, general fitness tests have been problematic, since one has proved them to be discriminatory and to lack sufficient evidence for their job-specific relevance (Ibid). The latter, again, is because one lacks knowledge about the actual and specific task demands of police work.

We, on the other hand, chose to carry out general fitness tests. Although we recognized the occupational performance-tests as having importance in enhancing our understanding about this subject matter, this was not where the main focus lay in our work. In fact, to me at least, this underlines again the continuation and symbiosis in my professional practice and the great consistency in my work despite the variations of the contexts in which I am situated. As an exercise scientist, with this physiology-laboratory mind-set affecting my point of view, the specific physical

[3] Construct validity in relation to general objective tests vs. more specific/functional tests is also addressed in chapter three.

performances in police work was not what I was looking for. I was more interested in the underlying physical abilities behind these performances. I was interested in detecting objectified, normative quantified physical parameters, based on precise and reliable measuring methods. Furthermore, in a more general perspective, as an exercise physiologist, I am concerned with the study of the human-body function. I am interested in how the different parts of the body work, separately and together, and how these body functions alter when the onset of physical activity challenges the homeostasis. In addition, I also have this sport-physiology baggage with me, making me concerned with how our body functions according to the context-specific demands in which any specific human operates. Without these surrounding frames, as I have elaborated, we stand the risk of not being able to clearly see the direction for any assessment applied, thus making it somewhat arbitrary.

We cannot just settle with the notion that general physical tests, either performance or more health related, have minor interest than more specific performance simulation tests, because the evidence founding these tests are lacking. On the contrary, we have to establish this knowledge foundation. We have to enhance our understanding of the activity profile of policing. We need to determine the underlying physical abilities behind any physical task the police have to execute. More knowledge about the main limiting factors behind any physical performance is required. We have to attempt better to understand which muscles are involved, and to what extent and in what manner they are involved, during various police tasks. We need to advance our understanding of the processes of force-development and the energy-delivery systems activated under different policing circumstance; and we need to discover what the limiting parts in these chain reactions are. Furthermore, for each type of physical task we have to gain evidence of duration, frequency and intensity, and not solely self-reported data, but actual objective measurements.

As already problematized, this frame is something of a missing link in my work within the police context. A systematic investigation, exploring the activity profile of the police occupation within this scope of exercise-physiology, is hence needed. Since this police context is the context in which I am currently situated, this, for me, appears as the next natural progressive step in the development of my professional practice. When such knowledge foundation is developed, it will become easier to attain a consensus regarding how to assess the physical abilities, and the critical values or standards, police officers need to uphold, in order to be capable of doing their job in a satisfactory manner. This knowledge will hence further develop both a conceptual and methodical well-established knowledge base, making assessing physical demands and physical fitness in the police less arbitrary than at the present time.

If we, however, again, compare such an approach to the police occupation with a similar approach to soccer, there are perhaps some elements making the police-approach somewhat more complicated. In police work, in general, there are more variations and a higher task complexity compared to soccer, making police work regarded as a more open task. In soccer, there are also, naturally enough, a more static environment (it is all taking place at a beforehand given pitch). Furthermore, soccer is to a high degree a universal activity, based on a set of clearly pre-defined rules of play, compared to policing. In regards to police work, it exists both a large-scale diversity of tasks to be solved, as well as a diversity in how to solve these tasks. Further, although the causality behind these variations are complex, possible explanations could be (inter-)national variations in crime-picture, police-education and jurisdiction. Another element becoming visible concerning methodical challenges related to police work is that whatever methods applied, at least in real-life active duty assessments, the methods cannot intertwine with officers

performing their job. Although this is an issue in soccer as well, I believe the severity is extensively higher for the police occupation compared to any athletic context.

These issues are of course making the assessment and evaluation of physical fitness related to police work more difficult compared to soccer. Another element is that within soccer, though of course dependent of the size of the effect, any attendant will have a natural adaption to the physical requirements of participating in normal game-play. Measuring elite soccer players' physical attributes, or characteristics, and comparing these to other groups of athletes will therefore be quite informative, since it at least to some extent, will reveal what demands the players are facing during play. For the police occupation, the same connection is not present. A major part of everyday police work is sedentary; meaning that many of the (critical) physical tasks officers need to perform occur so infrequently, that it does not have an influence upon their capabilities. The occupation itself is thus not physically demanding enough to develop or maintain the officers' fitness. Hence, due to a much more heterogeneous group of police officers, compared to soccer players, obtaining data on their physical fitness alone does not give any satisfactory knowledge regarding what the occupation really demands.

Nonetheless, although there are some methodical issues, which we have to take into consideration, this does not mean that an exploration of the activity profile of the police occupation from this exercise-physiology (laboratory) point of view is impossible. To me, again, conducting such studies appears as the vital next step to proceed on in my endeavors, a natural continuation of my professional practice. Of course, we have to acknowledge that we in this context, compared to other disciplines such as soccer, have come a shorter distance. This does however not imply that the work cannot be done. We have to begin somewhere; and it is not as if we have begun this work from some kind of zero point. We have found support in

the police-specific evidence, although it does not yet come from a well-established discipline upholding any universal conceptual or methodical consensus, that actually exist, and in my proceedings I will continue to find support in this evidence. Furthermore, as elaborated above, I have found, and will continue to find support in all my previous conduct. Every experience gained in one context is brought along to the next. To me this reveals a great consistency in my work: my professional practice as a sport and exercise scientist is expanding.

If we were to take a more specific glance at the great consistency present in my overall scientific conduct, we will see that from the occurrence of a scientific problem to the moment when I write down the conclusion, there are numerous commonalities between the various works: the way the intentions arise, which, in turn, leads to formation of the studies clearly defined purposes; the reliance on methodical rigidity and careful control put in operation through objective and standardized procedures; the acquisition of empirical data; the systematization and quantification of observations; the use of statistical analyses to examine means, variances, relationships and causalities between variables; and lastly, the structure and format of the scientific reports. Moreover, one of the most distinctive features of my work is that all the studies aim to detect and present some kind of objective normative universal truth. In a manner it feels as if my whole scientific practice revolves around these truths and hence that my everyday work is mainly directed at how to establish them: That if I just follow some kind of rigid and standardized scientific method, these absolute truths, which seemingly exist out there, are within my reach.

Furthermore, it even seems as if I uphold the conception that these objective truths do not exist until the data has gone through the whole of this scientific machinery. That it is through the completion of a work, manifested by the professional clarity,

precision and firmness of the published paper, that these truths are first established. The establishment of these truths is obviously important. They provide new insights concerning various human practices, as well as the potential for these practices to be improved. Hence, the dissemination of this knowledge to a wider audience is an important part of the scientific process. Yet, I find my own belief in the superiority of these scientific methods, the scientific machinery, as a whole, and the absolute truths that come out of it, a bit odd. Looking back now, I see that the intentions behind the different studies, to a great degree, are related to a desire to enhance my own knowledge of the various subject matters; and clearly, they have contributed in doing so. However, my personal knowledge is not dependent on the studies being published. The subject matters did not pop up as total strangers. They are more like topics that I have a great interest in, and how much I know about them is the result of a gradual development through working with them over longer periods. Still, it is as though my personal knowledge has a lower degree of trustworthiness and legitimacy, until the scientific process is completed in its entirety, and I cannot help but wonder why I have such feelings. As if, instead of submitting the papers to peer-reviewed journals I had put them in my desk drawer, and, as a consequence, my own knowledge of the topics would be less valuable.

Through this review of my published papers, I have thus become more aware of what I have done in my scientific practice and how I have done it. Any justification for these doings, and, even more important, for this strong – almost naïve - confidence in these doings, are, however, harder to give. This pathway of pursuing the natural sciences, as previously described, was not something like a fully conscious choice that I made: It was more like it just happened, as if I almost fell into it and unconsciously both preserved and carried on its fundamental assumptions. Therefore, I cannot help but wonder if the deeper questions concerning the underlying, and determining, elements, or forces, of this conduct are something

about which I perhaps have not thought thoroughly enough. As a natural scientist, I am standing within the modern science and knowledge tradition (Ponterotto, 2005), and, in fact, I believe it is this tradition's rules of conduct I have embraced in my practice. Hence, it is clear to me that further to enhance my understanding of my professional practice, I have to explore the fundamental thoughts within this tradition more closely.

# III. Going deeper: The ontological and epistemological basis of modern natural science

The modern science and knowledge view had its origin in the theory of positivism, which again had its source in the early physical sciences. Positivism was regarded as a single movement and it was believed that all sciences could be integrated in one unifying scientific method. The theory arose in the seventeenth century when ancient tests of reasonableness were gradually replaced with a particular view upon rationalism, in the pursuit of knowledge (Toulmin, 2003, in McNamee, 2005, p. 5). It held a strong belief in the human intellect, which was thought to have developed through three historical stages: the religious, consisting of myths and beliefs; the philosophical, with its metaphysical speculations; and the scientific, understood as perfect knowledge (Navon, 2001). The latter can also be viewed as the very foundation of the term positivism: the belief that only certain kinds of knowledge were scientific, which could be expressed as, "I'm positive I'm right because my position is founded on science" (Hess, 1997, p. 8). It is also necessary to see positivistic thought as a part of the history of progress and social stability. The term positivism, hence, can be understood as part of, and a contribution to, this positive development (Cox and Hassard, 2005). Nonetheless, the production and accumulation of scientific knowledge in the modern world had begun.

Historically, positivistic science has been described as the gold standard for conducting research (Guba and Lincoln, 1994, pp. 105-106). One of the most prominent features of positivism was the belief in the possibility to make universal generalizations independent of situational and/or historical context (Cox and Hassard, 2005, Johnson and Onwuegbuzie, 2004). Through an objectivistic and dualistic methodical approach, the positivist could be described as a neutral, distanced or disinterested observer (Plack, 2005), who conducted his research

through a *one-way mirror* (Guba and Lincoln, 1994, p. 110). Further, the positivistic scientist aimed to explore, predict and control the physical world (Plack, 2005). By conducting experiments in controlled environments, he attempted to find support for his observations and to develop hypotheses and theories that could be generalized (McNamee, 2005, p. 5). He also believed in the predetermined world as something that merely lay before him, ready to be captured, described and explained. In this mind-set, new knowledge meant the discovery of things, as they were (Guba and Lincoln, 1994, p. 109). This implied that experience or observation was the very beginning of knowledge; without experience, the human mind was a *tabula rasa* (blank sheet) (Hollis, 1994, in Parry, 2005, p. 23). This way of thinking had methodological implications, where experimental and quasi-experimental designs, intervention, manipulation and thoroughly defined methods were especially emphasized (Plack, 2005), and where by linear quantitative methods, hypotheses were tested and ultimately verified or rejected.

In the early twentieth century, positivism took a new turn, and what came to be called logical positivism "formed the basis of modern scientific thought" (Crotty, 1998, in Plack, 2005, p. 227). With this new turn, language became especially important, and where a statement was only considered meaningful if it was verifiable (Hess, 1997, p. 9). Still, the basis for verifiability within positivism was experience, though some statements could be verified by logic. The process of verification of *a priori* hypotheses to detect final truths, laws of nature and human behavior was therefore the essential work of a positivist (Kim, 2003, in Plack, 2005, p. 226). Sentences were thought to be rational reconstructions of empirical data, thereby entailing a normative foundation (Nekrasas, 2005, p. 2), where a positivistic approach to meaning was based on a *project* to articulate a universal and formal language (Hess, 1997, p. 10). The quality of science could therefore be narrowed

down to how well this formal language was managed. Hence, the scientific paper became one of the most important elements of science.

An influential person in the development of the modern science and knowledge view was Popper. Some view him as a positivist (Hacking, 1983, in McNamee, 2005, p. 8). From my point of view, he might best be placed in the category of post-positivism. His best-known legacy is probably his reversal on how a scientist should think in the search for knowledge. Popper suggested that rather than striving to verify his hypotheses, the scientist ought to try to falsify them. He believed that a scientist had to attempt to reject weak statements or theories and try keeping only strong ones (Popper, 2002, p. 18). Another new way of thinking presented by Popper was his rejection of the belief in universal or absolute truths. He believed, on the contrary, that strong theories that had resisted falsification should be regarded as only temporary. They should never be understood as absolute knowledge, because they can never finally be verified (Ibid, p. 22). Scientific advancement was thus not determined by validation of statements or theories, but by their falsification. As time went by and a theory proved to be resistant to all efforts to falsify it, the scientist could however be increasingly confident in its correctness (Hess, 1997, p. 20).

Likewise, the positivistic conviction of the knowledge-developing process as an inductive process was not upheld by Popper (2002, p. 18). He argued that science never began with empirical data: “I do not believe that we ever make inductive generalizations in the sense that we start with observations and try to derive our theories from them” (Popper, 1957, in Kvernbekk, 2002, p. 38). Hence, he was skeptical of the ability to draw a conclusion from a number of observations of a given phenomenon, since in his view, certainty about what would happen tomorrow cannot be based on what happened today (Popper, 2002, p. 4). Quite the opposite,

Popper believed that all observations are determined by theory, that "theories shaped, constrained, or colored observations" (Hess, 1997, p. 18). The very beginning of any new knowledge is therefore a theory, from which one deduce observation-statements, which then again are tested against observation (Popper, 2002, pp. 9-10). However, Popper gave precedence to empirical data over theory, so if an observation did not match the theory, it is the theory that must be rejected. Yet, in practice, this implied that a scientist starts his work with a conclusion, from which he then verbalizes a hypothesis, which finally, he tries to refute through observation (Ibid, pp. 9-10).

Further, in this view, science could not generate absolute, certain knowledge. Reality could only be imperfectly apprehended (Guba & Lincoln, 1994, p. 110) and science could only predict, with a certain level of confidence, the probability of a given occurrence (McNamee, 2005, p. 9). This elevated the quantitative approach introduced by positivism and to some extent narrowed science down to only its statistical methods. This had the effect of pouring fuel on an already beginning fire and at this point, positivism and its allies were attacked from all sides (Ibid, p. 10). Bogen (2001, in McNamee, 2005, p. 10) described the problem as based on a *positivistic naivety* regarding the process of scientific work. He claimed further that "the fabulous engine called the scientific method", in its lack of accurate methods for analysis, often ended up with "messy, quirky techniques and devices for producing and interpreting empirical data" (ibid, p. 10).

## Finding it inadequate

The modern science and knowledge view was thus increasingly met with skepticism and critique from other scientists and philosophers. One of the first critics was Kuhn, and Popper was one of his main targets. In contrast to Popper's opinion, Kuhn

argued that although a scientist might be faced with anomalies or refuting instances, he does not stop to work under a theory or a set of theories (Hess, 1997, p. 24). Scientists did not attempt to falsify their own hypotheses. On the contrary, they pursued evidence of support. To Kuhn this was his view of *normal science,* which he described as a way of solving the puzzle of apparent challenges. Further, a majority of scientists would presumably claim the inductive approach of positivism to be a more realistic picture of their everyday scientific practice compared to Poppers deductive approach (Kvernbekk, 2002, p. 28). Kuhn therefore described the work of everyday scientists as not very *Popperianic* (Ibid, p. 28).

The critique was also aimed at the modern belief in the unity of science: the idea that scientific theories from different disciplines were not to be viewed as opposing each other. Scientific agreement in one discipline could therefore be conveyed and generalized into other disciplines (Hess, 1997, p. 15). This was considered one of the major anchor points of positivistic thought in general: the transfer between the natural sciences and the social sciences and the humanities. Methodological and epistemological divergences related to explanation versus interpretation were emphasized as problematic (Hess, 1997, p. 15). The positivistic epistemology was associated with nomothetic research methodology, where the goal of science allegedly is based "upon systematic protocol and technique" (Burrell and Morgan, 1979, in Cox and Hassard, 2005, p. 114). This was compared to the more subjectivist approaches, which supported an ideographic methodology, and where the goal of science was to investigate subjects unfolding in their natural context (Ibid, p. 114). The two views were claimed to be incommensurable and the gap between them, unbridgeable (Giere, 1988, in Hess, 1997, p. 12), thus refuting the idea of the unity of science.

Another important criticism of the modern knowledge and science view was directed at its emphasis on mere description - that is, providing objective but superficial descriptions of a given phenomenon without any attempt at deeper understanding or interpretation. As new, more complex objects gradually and increasingly came under the scientific microscope such as human beings, their capture, representation and transmission became more difficult compared to the simpler natural objects previously investigated (Cox and Hassard, 2005). Many of the new phenomena were too complicated to predict (Hess, 1997, p. 16), and when the goal of the scientific conduct was no longer simply to *describe* an already finished picture, but to contribute in *constructing* the picture, the adequacy of quantitative methods came into question (Cox and Hassard, 2005). Another thing criticized was that the static and predetermined phenomena of the world, which one engaged in modern science is said to believe in, in the next phase, were met with an adjustable language to meet the requirements of their portrait (Ibid). The only way to consider the content and outcome of science would thereby be by reading scientific papers in which this language was expressed.

Latour (1987), however, described all textual concepts presented in a scientific paper as merely semiotic actors. They were thus not presented in the flesh – he described it as "they were alluded to as if they existed independently from the text; they could have been invented" (p. 64). In the modern view's rather one-sided focus on the written products alone, when assessing science, perhaps we are missing the actual content of this conduct. To Latour, however, the scientific papers are just end products, and even end products of a longer and more difficult process than they give the impression of (pp. 64-70). The process of knowledge development is more complex than, and not as straightforward as the modern scientific view would like it to be. In the search for the determining elements of my practice, I hence believe this view simply comes up short: It feels as if I am still only surfacing. To come any

farther, I thus have to go beyond the evident: To go beneath the surface, and follow Latour behind the scientific papers.

# IV. Into the deepest: Behind the evident

## My Scientific Practice

### *Research idea*

*A quiet knock sounds on my door. Through the crack I can slightly see Per's face. "It's two o'clock," he says; then, he is out of sight. To break the pattern of much solitary office work, two colleagues and I have agreed to meet regularly for two o'clock tea. It is not necessarily a daily routine, but this gathering provides us with an opportunity to meet, share and discuss whatever work with which we are currently concerned. Sometimes these informal talks take up issues from the private sphere, though more often they develop into discussions related to topics of a more professional nature. As all of us work at the sport section, concerned with exercise and sport physiology, this is often the direction our discussions take. If there is, or has been, any activity in the physiology testing laboratory this is a potential subject of interest. This day, as an elite female soccer team had just completed their endurance tests, our talk developed into a discussion about how this team performed compared to other female soccer teams, both nationally and internationally. The male soccer players' endurance performances were well known; however, there was no information regarding female players. Neither of us knew of any published data available for comparison. Thus, we had no firm evidence, no knowledge, to support our beliefs, and, hence, this was when the research idea aroused: Why not be the ones to start building this knowledge bank, scientifically to establish normative data on female elite soccer players' aerobic capacity?*

*Before embarking on this project, though, we had to assure ourselves that no one had carried out this research previously. However, a literature review gratifyingly confirmed our assumptions, and the commencement of the study could thus be justified. Furthermore, besides proving the relevance of the project, the literature*

*review gave an overview of the topic we aimed to explore, as well as informing us of several journals toward which it would be relevant to aim the publication. After some consideration, we decided on a journal that emphasized the practical application of the conducted studies, which we thought was suitable for us. To decide what journal to aim for at such an early stage also seemed beneficial, since it enabled us to target the work more specifically toward the journal´s expectations and requirements from the beginning.*

*With the decision to initiate the project, a feeling of uncertainty came creeping: It felt a bit hasty and I could not help but question whether we were really up for the task. Even though we were experienced exercise physiologists, well accustomed to scientific work, and even though both my colleagues already had co-authored a scientific paper, we at this point were in uncharted waters. Conducting a scientific study of this type on our own was not something we had attempted previously. None of us at the time were formally trained scientists (holding a PhD), we had no supervisors in regard to this project, and in a way it felt as if, at least I, jumped into something for which I perhaps was not qualified. However, after a short time these feelings disappeared. There was no regret upon the decision: This was something I wanted to do, something I wanted to learn and master.*

*The next thing we had to think about was how, specifically and concretely, to carry out the project. Which variables did we want to explore and how could we do so? Considering the purpose of the study - which was to obtain objective data on female elite soccer players' aerobic capacity characteristics - the answer to these questions seemed predetermined. The knowledge basis we wanted to start building had to relate to the same variables we were already collecting information about through regular testing activity in the laboratory. The selection of the study's variables, and the standardized measuring methods for assessing these variables, therefore*

*followed logically from the project's general intention. Furthermore, the choice to use these tests also seemed feasible according to both practical and financial considerations.*

*Nevertheless, although the issues of the study's variables and measuring procedures were settled, and the fact had been established that aerobic capacity was an important contributing factor in the physical performance in soccer (Reilly, 1997), we still had doubts about how well these tests would enable us to assess this feature in soccer players. The two main variables we aimed to explore were maximal oxygen consumption (VO2max) and anaerobic threshold (AT), both of which are important underlying factors behind aerobic capacity. In fact, the test of VO2max is generally considered the most objective and valid test for measuring the aerobic energy delivery system, which is also proven to be closely related to soccer performance (Bangsbo, 1994, Smaros, 1980). AT is also emphasized as a good indicator of the aerobic energy delivery system, and it has been speculated whether it is more accurate than VO2max, as it can change without an accompanying change in VO2max (Allen et al., 1985, Bishop et al., 1998). Anyway, together the two laboratory tests for detecting these two variables make a reliable pair for measuring general aerobic endurance (Svensson and Drust, 2005). Their functionality and (construct-) validity regarding soccer-specific endurance, however, have been questioned (Bangsbo et al., 2008, Krustrup et al., 2003). The questions concern how well they can document changes in, and differences between, players, and their ability to register seasonal variations (Krustrup et al., 2003, Reilly et al., 2000.*

*In response, several field-based tests have been developed with the intent of better highlighting the specific endurance demands of soccer. Although a relationship between laboratory tests and endurance performance in soccer has been documented, the relationship between some of the field tests and performance is*

*even stronger. Hence, soccer-specific endurance is supposedly more visible in these field tests (Bangsbo et al., 2008). On the other hand, relationships between the field tests and the laboratory tests have also been established, and VO2max is consistently emphasized as a direct underlying factor that affects performance in the field tests (Pettersen, 2007). Hence, even though some of the field-based tests may be more functional for assessing soccer-specific endurance, the laboratory tests are considered valid general measures of aerobic capacity. Furthermore, our objective was not to describe any soccer player performance or performance-related tests; on the contrary, our objective was to reveal underlying physiological factors behind such performances.*

*We believed the most interesting data to explore were average values for the team as a whole. Since research on male soccer players has revealed differences in physical capacity according to different playing positions on the team, we also aimed to find average data on the players in four categories based on position. A descriptive cross-sectional design seemed best suited for this purpose, and we decided that the collection of data should take place the next time the female elite soccer team came to the laboratory for regular testing. Although not exactly an experimental design, this design nevertheless has, according to Ringdal (2013), an experimental character. The data production was to take place in a laboratory, where we could "structure the situation and manipulate one or several variables that could be regarded as experimental factors" (p. 121). Of course, we understood that a non-randomized sampling could lead to biased data and thus decrease our abilities to uphold both statistical and external validity. Yet we, as quite often done (p. 213) due to the factors described in the recapitulation, made our choices based on practical and financial reasons. We were dealing with elite athletes, from a somewhat small, at least actually available, population, and the participation required them to carry out exhaustive physical testing in our laboratory. Accordingly,*

*the advantage of using such a convenient design is the low costs associated with it, the practical feasibility, as well as the fact that it is useful for describing a population at a given moment of time. One can easily detect the characteristics of the sample, identify relationships and generalize the findings back to the specific population (Gratton and Jones, 2004, pp. 94-95). However, it is not possible to generalize beyond the specific population, although one can regard the findings as transferable. Hence, although there were methodical limitations, we thought this study could provide knowledge of both practical and scientific interest.*

***In the laboratory***

*Everything is ready. All lists and documents have been checked, the laboratory has been prepared, all equipment has been calibrated and all mouthpieces, tubes and air hoses have been cleaned and disinfected according to the manufacturers' manuals and descriptions. Anne, who is the first subject, is brought to the laboratory. She is an experienced subject, having previously completed numerous tests. Because of her previous visits to the laboratory, and since I have worked as a physical trainer with the team and met her in that context, I know her quite well. For this reason, she is my favorite kind of subject: She knows exactly what will happen and what to do. In contrast to what is the case with more inexperienced subjects, I can allow myself to be a little less hands-on in giving instructions and information about testing and safety procedures. Of course, it is not as if these parts are not secured, but it does not have to be done so thorough. To a large extent, I can devote my attention to observing the subject and the physiological parameters under examination. Moreover, it is less likely that something will go wrong, and thus, that the rather tight schedule of the day will be threatened. When I glance at Anne's shoes as she enters the lab, these thoughts are immediately reinforced. She has not tied her shoelaces because she knows the first thing we will do is a weight measurement, and that she, for this reason, has to take her shoes off. When the weighing is completed,*

*she fills out a short questionnaire, puts on a heart rate monitor, and then she is ready. She steps onto the treadmill, yet, there is something about the way she does so that catches my attention, something almost uncoordinated or ungraceful in the way she moves, which I find unusual for her.*

*Anyway, I start the anaerobic threshold test. Due to the low initial speed, I can give the required instructions about procedures, once the test has begun. What starts out as an informative speech, however, gradually evolves into a dialogue, which I use actively to gather information about Anne. Although the questionnaire allows me to gather some background information, I use this dialogue to elaborate or clarify where and when necessary. I ask if she has slept normally for the last few days, if there are any dietary abnormalities, any injuries or illnesses of which I need to be aware. I also ask her about the exercise load over the preceding days and months. I also query whether she feels well rested, and how she rates her fitness level in general. All these issues are potential elements that have to be accounted for in the interpretation of the physiological data produced in the test.*

*The purpose of the anaerobic threshold test is to disclose, precisely, the subject's anaerobic threshold (AT). There are several names for and ways to interpret AT, yet each describes the same physiological occurrence: the highest intensity at which a steady state still is achievable during long-duration exercise. At intensity levels above this point, it is not possible to sustain equilibrium in energy metabolism, with the consequence being fatigue, and eventually, exhaustion. During high-intensity, constant-work-rate exercise, energy production relies (mainly) on glycogen metabolism. In this process glycogen goes through several linked stages, and, simplified, what happens, when exercising above AT, can be described as some stages being unable to maintain the same speed as at other stages. This involves highly complex physiological processes, where the exact causal patterns are not*

*finally determined. However, one of the main consequences of exercising above AT, which also forms the logic of the test, is the accumulation of the metabolic byproduct lactic acid (La) in the working muscles. Hence, we can define AT as the highest intensity level the subject can uphold, where there is still equilibrium between production and elimination of La, i.e., before accumulation occurs.*

*La is considered as a direct contributing factor to fatigue, as well as an indication that a limit has been reached in the relationship between energy demand and energy production. For this reason, one should note that in this test it is only lactate, which is one of the components of lactic acid, which is measured. What we really want to assess is the other component of La, hydrogen. However, for the sake of methodical simplicity, we measure lactate, and this is a reliable method since the two components increase proportionally. Another aspect we have to take into consideration is that lactate is most often measured in blood (capillary whole blood), and even though blood lactate corresponds to muscle lactate, entrance into the blood increases the complexity of interpretation. Thus, the number of contributing elements in the process increases, and, if we want to assess a change in pre- to post-test results, it is even more difficult to determine the causality of the alteration. Anyway, by performing endurance exercises, each individual can enhance his or her AT, implying that the limiting parts of the energy delivery chain are improved - the detectable result being that the subject can exercise at a higher level of intensity without La being accumulated.*

*In our laboratory, we use a standardized incremental discontinuous testing protocol on ergometer (most often a treadmill) to assess AT. In many laboratories AT is determined according to a predefined and standardized set lactate value. We, however, usually relate the analysis to the individual's initial lactate values measured at low to moderate intensity, where blood lactate is not substantially*

*elevated above resting levels. This method is not scientifically accepted and therefore, for a research project, we sometimes calculate AT according to a standardized value. The outcomes from the different assessments have not always had any particular practical significance, but still, in my experience, conducting thousands of tests, the validity of our individual-based method surpasses that of methods based on set values. The bodily adaption to physical exercise is dependent on the type of load applied to the organism, as well as the bodily preconditions of the individual. Consequently, we cannot in general interpret the lactate curves of athletes with different physical abilities and exercise and competition experiences in the same manner.*

*A key element in the test is the initial intensity. As mentioned above, if this is too high, the initial lactate values will be incorrect and, consequently, the test will not lead to valid results. Additionally, if the opening intensity is too low, the test duration becomes too long, implying subject exhaustion and thus similarly invalid results. Usually, we base the initial load on previous results, but if we have not tested the subject previously, we relate it to the subject's maximal heart rate. Yet, in these cases, we determine the exact treadmill speed by some informed guesswork. The test procedure consists of 5-7 intensity increments on a treadmill, usually 1 km/h for each increment, with each level held for five minutes, except for the first, which we hold for ten minutes. However, to ensure a valid test, I usually begin 1 km/h below the planned starting speed. In this manner, I give the subject a gradual approach to the exercise intensity, ensuring that we can conduct the intended procedure as planned. If the subject responds normally to this load, I then, five minutes into the test, increase the speed to the actual starting level. Today's testing is eight weeks into the preseason training period and based on this, as well as on Anne's statements about her own training and fitness level, I anticipate her performance to have improved since her last test. Hence, I expect her AT to occur at a higher load*

*than last time, and to avoid an extended duration of the test, the initiating load is set higher than in her previous test.*

*Four minutes into the test, running at 8 km/h, Anne's heart rate is 143 beats per minute. This is somewhat higher than expected. The expression on her face also seems to reveal a little concern. I recall my impression of her as she stepped on the treadmill minutes earlier. Something is not as it ought to be. Without revealing my worry, I ask her how she feels (implying, how do her body/legs feel). She looks at me and the expression in her eyes is confirmation enough. She then says, "Maybe yesterday's workout was more exhausting then I first thought. My legs feel a little bit heavy." This contradicts her earlier statements, and I feel a small frustration occurring deep within me. The team's coaches had been given clear instructions not to engage the players in anything more than low-intensity exercise in the two days prior to testing. This is critical to ensuring that the players are in a rested state upon arrival at the laboratory. However, deciding what low intensity means is not a straightforward matter; a consensus regarding what the term implies does not exist, especially when situated within a mixture-zone between scientists and practitioners (e.g., coaches). Another relevant factor is that when participating in team sports, like soccer, the natural joy of the game easily carries one away. Even though the intention is to conduct a low-intensity exercise, one cannot so easily maintain this while playing. Anyway, this development jeopardizes the whole test.*

*Of course, we might continue the test until the first blood lactate measurement is taken, and perhaps this value will be within the expected range. However, my intuition has told me that this is not very likely, and hence there is no reason to continue with the plan. I decide to decrease the treadmill speed to 7 km/h, and Anne agrees. At this early stage, only a minor adjustment like this can be enough to turn the scenario in the right direction. I am, nevertheless, somewhat uncertain about my*

*decision. I know from experience that this speed, for many females in particular, can be demanding. It becomes something in between walking and running, which often leads to an unfortunate technique and thus decreased work economy. However, Anne's heart rate drops immediately and after five minutes it is stabilized at 127 beats per minute. Then I gradually lower the treadmill speed and call Anne to the side for the first blood sample. She takes some small steps to the left of the 3-meter-wide treadmill and jumps off from it while it is still in motion. Her fingers are quite cold, which often implies that the finger pricking will be uncomfortable, and as I prick her finger, she makes a little noise as if to notify me of this.*

*Ten seconds later, she is back on the treadmill, now turned back up to 8 km/h, and as she continues her run, I wait with excitement for the lactate results. Our lactate analyzer is not the newest of its kind, and requires 60 seconds to determine the lactate level. Nonetheless, when the result shows a lactate value of 1.9 mmol, it is exactly what I had hoped. I also get objective confirmation that we are on the right track when three minutes later, Anne's heart rate stabilizes at 136 beats per minute, which is seven beats lower than the first time at this intensity level. This is a clear sign that this load now demands less of her. The physiological data are also supported by her body language, which now, in a way, expresses a kind of comfort. The test can proceed as planned.*

*Twenty-four minutes later Anne is running at 12 km/h. The test has so far progressed as expected and it is now one minute until the next blood sample. All observations indicate that we have reached the anaerobic threshold. Anne's heart rate is seven beats above where, on the heart rate curve, her AT was found the last time she was tested. Despite this, a clear breakpoint on her heart rate curve is still visible. This is a strong indicator that she has exceeded her AT. Furthermore, her breathing frequency and her breathing depth are significantly increased and her ability to converse*

*reduced. When I observe her even more closely, it is clear that her body temperature has increased: she is sweating quite a lot. It is also obvious that she is more devoted to the physical task, and that running at this speed requires more concentration from her compared to earlier stages. When I then turn down the speed and Anne, with a relief, steps aside, I am therefore quite confident that this is the last lactate measurement. Yet, the lactate value is still what determines the test's completion, and as I wait to verify my assumption, I send Anne back on the treadmill, now turned up to 13 km/h. Fifty seconds later the lactate analyzer beeps and discloses a lactate value of 4.7 mmol, which is substantially above her calculated threshold. I then stop the treadmill and give her a ten-minute pause to recuperate before the maximal oxygen consumption test.*

***Data interpretation***

*It is morning and I arrive at work a bit relaxed. After several days of hard laboratory work, the whole team has been tested. After a cup of coffee, I begin the paperwork. Although I have interpreted all data during and immediately after the tests, the assessment is not always straightforward, and therefore, I review all data once more. In this evaluation, it is sometimes necessary to withhold some data for a more thorough review, and, additionally, for some cases it is necessary to obtain a second opinion. If a colleague has led a test, I do not have access to the same information as when I have led the test myself. In these cases, I thus have to obtain this information from him or her. In some cases, this can be challenging, since we might see things slightly differently, and accordingly, respond differently to a given scenario. In general, this has no practical implications for the results of the tests, but as I am concerned with details, I have to gather as much information as possible to ensure valid data interpretation. In this connection, an evaluation meeting for the involved test leaders is arranged. Here, we assess all results and possible concerns, and, if disagreements occur, discuss arguments for the different views. We debate various*

*ways of interpreting the data and most often achieve a consensus regarding the most trustworthy interpretation.*

*When we have reached an agreement upon each variable's value, we can begin the work of establishing a worksheet for the study. Our aim is to disclose average values for anaerobic threshold and maximal oxygen consumption, as well as for some associated variables, for the team as a whole and according to different player positions. We also want to determine whether any between-group differences (according to their different positions) exist, more specifically which groups differ and whether these potential differences are statistically significant. Although we have done similar statistical work numerous times, this is not something we necessarily can by rote. To me it feels more as if the challenges, in a manner, have to be resolved from scratch each time, and, to ensure that I get things right, I am fairly dependent on my statistical survival manual.*[4]

*After some familiarization to the problem at hand, we decide to do a one-way analysis of variance followed by a Tukey post-hoc test.*[5] *However, to carry out this procedure we first have to explore whether the variables are normally distributed and whether any difference in variance exists between the positional groups, and we conduct these assessments by a Shapiro-Wilk's test and a Levene's test, respectively. When we then begin the practical work of following the steps of the statistical procedures, we immediately discover that it is not as easy to accomplish as the survival manual might suggest. Yet, after some trial and error, the outcomes of the analysis are finally, and repeatedly, consistent.*

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[4] Pallant, J. 2010. *SPSS. Survival manual. A step by step guide to data analysis using the SPSS program*, 4th edition. Open University Press, Berkshire, England.

[5] When conducting analysis of variance, one examines if significant differences exist between all included groups. A post-hoc test must also be conducted if there is a need to find out which groups among all the groups significantly differ.

***Manuscript work***

*Although we started working with the manuscript from the outset of this project, it is first when our results are ready that we are able to intensify this work. For me the writing process does not consist merely of writing; it is as much about thinking. The completion of a sentence, or a paragraph, can occasionally take hours or even days. This has two sides, connected to each other: linguistic precision and correctness, and academic precision and correctness. Therefore, along with my endeavor to produce a good text, it follows an endeavor to improve my understanding of the particular subject matter. In the early stages of this work, as I sit in my office, as I read and write, I also follow my trains of thought where they take me. Previously, I had felt some anxiety about or resistance to embarking upon these stages of creative chaos, or head spin, comprehending them as something that distracted me from the real work. Gradually, however, I have come to realize that this is both a necessary and quite important part of the process, which I have to meet with open arms. I now believe this wide approach to my work makes me capable of reaching an overview, that is, a form of mental image of the entirety of the task. This sets me in the position to see clearly the rationale, content and natural structure of the text. When this basis is established, I then begin the process of refining and sharpening the text. Every part goes through a filtration and gradually the finished product appears. Furthermore, characteristic of this part of the work is that I, as I remember it, felt it was important to prepare the text so that it appeared with a high level of clarity and certainty. As if, I, by showing some firmness, could better convince the journal and its readers that I had something of significance to present, although I was perhaps not so sure of this myself.*

***Publishing***

*All references are converted to plain text, implying that the endnote link is disabled. Then, to ensure that the conversion does not change the structure of the text, we*

*read the paper thoroughly a last time. Finally, we are finished. The paper has been prepared in accordance with the journal's guidelines and is ready for submission. Through the journal's website, we upload all necessary documents, and after some communication back and forth, we receive confirmation from the journal editorial board: "Submission completed." A slight sense of doubt immediately occurs. We have reached the moment when this work no longer involves only the three of us. The impact of our actions has increased; we have placed our fate in the hands of others, and the outcome of the situation is no longer for us to control. Furthermore, we have not submitted the paper just anywhere: We have sent it to an international, highly esteemed sport sciences journal. A question thus arises: Do we really know what we have done? Still, a few seconds later, a feeling of great joy replaces the doubt. We have completed the work.*

*Six months later the decisive moment arrives. The subject line of the email from the editor board strikes us with anticipation and excitement: "Decision on manuscript entitled …" The text states that two peers have reviewed the manuscript and decided that it needs major revision before the journal can further consider acceptance of the paper. The critique from the reviewers is both long and comprehensive, and it feels like responding to it will be impossible. The previous feeling of pleasure upon submitting the manuscript dissolves as we realize that we are not even close to the finish line. In some ways, it feels as if we have to do the work all over again. A feeling of disappointment and frustration strikes us. Of course, we agree that the decision could have been worse; we could have been rejected at this point. Still, we did not anticipate the extent of the review and the amount of work required to complete the revision.*

*On the other hand, based on our lack of experience this was perhaps the best for which we could have hoped. We engaged in this scientific game with the aim of*

*learning, and thus, by this reminder, our motivation reoccurs. As we begin the revision process, and as we go deeper into the reviewers' comments, the motivation continues to intensify. A strong belief that it is possible to revise the paper and have it accepted replaces our initial feeling of powerlessness. Required revisions are then made, responses to the different points from reviewers are written and lastly a response letter to the editors is written. The paper is resubmitted. We all agree that the revision process has forced us to go deeper, to try harder, to be clearer, and better to emphasize the significance of our study. However, we also, where we disagree, give thorough arguments against the reviewers' critique. Nevertheless, there is no doubt in our minds that this process has resulted in an improved paper, and maybe even more importantly, we have learned from it and gained valuable experience.*

*Eight weeks later a new email arrives from the journal's editor board: "Final decision on the manuscript entitled … pleased to inform you that the paper in its present form is accepted for publication in …"*

# V. Going outward again: The contours of an expanded ontological and epistemological basis

## Science as a Human Practice

### The Pre-given Picture

Based on this deep-dive within my scientific practice, I wonder whether my initial notion of being able to establish some absolute knowledge independently of my own active participation, needs some adjustment. My slightly naïve and simplistic belief in the existence of some kind of predetermined objective facts that I, somewhat disinterested, was to collect and then just present in scientific papers seems not to fit very well to this narrative. On the contrary, I believe this description reveals a higher complexity, and that there is more work involved, in the knowledge-producing chain than modern science and the linear scientific method suggest. My work does not solitarily consist in the collection of empirical and objective facts of the world, which I thereafter simply present in scientific papers. The scientific knowledge that comes out of my work is more like results of numerous human actions exerted by my colleagues, and me separately, and together, where the road towards this point, when we have achieved reliable and valid results, is both long and winding.

For instance, as it emerged in the deep-dive narrative, first, I have to be able to operate different instruments in a satisfactory manner, including proper calibration in advance. Second, I have to apply the proper procedures in regards to the purpose of the tests. Third, in the interpretation of the results, I have to understand the physiology behind the data the instruments deliver. Fourth, I have to connect all the observations made during the tests to each other and to their context. Fifth, I have continually to respond correctly according to the different observations and/or the interpretations that I make during the experiment; and lastly, I have to process the

data that results from the tests with the right analysis in the right manner. Even though I follow standardized protocols and procedures, this does not take place without human interaction.

My scientific work does thus not consist solely of pushing buttons and then just watching the collection of data being accomplished. There are obstacles and problems that I have to solve and resolve over and over again. Further, these obstacles or problems do not come with a predetermined solution: the general rules of scientific conduct I apply in the laboratory have to meet the specific subject in the specific conditions, every time. In this practice, there are a myriad of considerations, interpretations, judgments, decisions and actions to make, and it is I as a scientist that have to make these. To be able to get things right, I believe my own experience is my best guide: experience, in which I over considerable time have acquired, developed and refined precisely those considerations, interpretations, judgments, decisions and actions in the face of exactly the same type of obstacles and problems.

There is however no doubt in the necessity of procedures and protocols within my practice, and this connection, between human action and experience on the one hand, and the dependence on standardized procedures on the other hand, makes me think of Lindseth's (2014, pp. 45-46) description of the craft of seamanship. Seamen can base their practical actions to a large extent on routines and technology; however, when something unexpected occurs, such as the weather turning bad, their own experience becomes an absolute necessity. The extent to which they are able safely to continue toward their destination becomes dependable on whether they have been out in such weather before, as well as their familiarity with the particular waters where they are positioned. In regards to the scientific work done in my laboratory, unforeseen incidents occur frequently, and

my abilities to handle them well depend on my own experience. With Anne, the whole test at one point was at stake, where a continuation of the commenced test procedure most likely would not have given a valid outcome. However, as described, I knew Anne, as well as the fact that I had faced similar situations and conditions previously and this was what made it possible for me to make the necessary adjustment to the protocol.

This brings me to an even more fragile part of this problem-solving, knowledge-production chain: the dependence on the ability to first spot and then correctly to define the given problem. Already as Anne stepped onto the treadmill, I saw something, a lack of ease, which caught my attention. Later it was an expression on her face, which occurred at a moment in the test when I did not expect it, that made me aware something was amiss. Lastly, the increase in her heart rate, to an extent I had not presumed it should be at that point in the test, triggered my attention. The combining of these early signals made me increasingly feel that something was not as it should be, and they ultimately made it possible to take the appropriate actions before the test had to be terminated. Again, what made this possible was the fact that I knew Anne. I had observed her, as well as other athletes in somewhat similar conditions, many times before both inside and outside the laboratory. When I combined this knowledge with my knowledge of human physiology, the proper action was possible to take.

My own involvement in this knowledge-producing process also reveals a different vulnerability of the scientific conduct than what I previously have acknowledged. I cannot just rely on a solid scientific machinery; on the contrary, it is I as the scientist who is the most crucial part of the whole chain of scientific conduct. I am not only a passive observer of the world; perhaps a more trustworthy description is that I am something like a film director, someone that runs the whole operation (Butson and

Thomson, 2011, p. 10, Henley, 1998, in Shrum et al., 2005). It is I, who structure the situation. It is I, who aim my focus and attention toward what I choose. It is I who use the technological instruments as extensions of my intentions, like a camera I point in the desired direction, zooming in and out, as I want, and thereby deciding what the camera should not be pointing at (Butson and Thomson, 2011, p. 10, Korkiakangas, 2014, Noland, 2006, Shrum et al., 2005).

The human involvement in the production of scientific data is something both increasingly addressed and increasingly accredited, within the post-modern, constructivist, scientific thoughts (McNamee, 2005, p. 10). How the scientist actually managed his work, was emphasized, leading to a dedication to give more truthful descriptions about the practical work scientists engaged in (McNamee, 2005, p. 11). This, call it the new way of approaching science, may also be understood as a rejection of the "black box" model for scientific work as a phenomenon; one previously knew about the input and output of science, but not about the internal contents (Hess, 1997, p. 81). However, the internal content now slowly came to the surface. It became clear that important work existed behind each written product, and when, for example, entering a science laboratory the images of a written text became visible - one could see what they were made of (Latour, 1987, p. 63).

One of the major twists of this new approach was that scientific work became acknowledged as a human practice, dependent on "human intellect, interests, resources, relations and intentions" (Kvernbekk, 2002, p. 69), and that it in fact were these elements that determined the whole scientific process by controlling what topics and questions that was put to examination. It thus became clear that scientific data did not collect themselves, and that selected parameters did not choose themselves either; it was the scientist who performed these tasks (Ibid, p. 69). My choice of exploring soccer players' general endurance capacity, measured

by laboratory tests, is understandably not a random choice. I had worked in an endurance laboratory and tested soccer players for years, as well as played soccer myself. Hence, the topic was something I was deeply interested in and something I was eager to know more about.

Nevertheless, the emphasis on science as a human practice did not make it easier to understand (Latour, 1987, p. 67). Scientific work, as laboratory work, was disclosed as a multifactorial, prolonged and complicated process consisting of ongoing preparations, calibrations and experimentations (Ibid, pp. 63-70). Furthermore, it was gradually understood that the actual scientific practice was much messier than what a published paper might suggest: it became clear that the work inside the laboratory consisted of countless trials, fixings and rehearsals (Ibid, p. 67). In the process of producing valid scientific data, there are countless potential pitfalls into which the scientist may fall. In my opinion, this description appears quite truthful. In a manner, it feels as if I have fallen into every pitfall possible.

Another element concerning scientific work, realized in the post-modern view, was the dependency on the technology behind the *cleaned and displayed* texts, figures and arguments within a scientific paper (Ibid, p. 65). Both how new knowledge was dependent on technological development and the scientist´s ability to interpret the data that the instruments produced, was gradually more highlighted (Ibid, p. 65). In my work, the interpretations were primarily accomplished continually during the tests and immediately after the tests were completed. Due to the data´s complexity, and the rapid succession of these interpretations, however, they were reviewed once again later. In this connection, the review also had a discursive aspect since the data and their interpretations were discussed with other physiologists. Måseide (2006) describes how the production of scientific facts is highly dependent on such collaborative discussions within groups of scientists, and how this aspect has been

ignored when interpreting the outcomes of technical instruments. Such problem-solving processes, where judgments and decisions are discursively constructed, are, according to him, viewed as one of the main arenas of practical science.

How the production of knowledge is anchored in local settings was also something one had overlooked, on the modern view. In post-modern, constructivist, thoughts, however, this understanding gradually developed. How scientific practice, and the decision making within, was affected by both contextual and situational factors, such as laboratory equipment, surrounding environments and different materials or procedures, became highlighted (Hess, 1997, pp. 100-101; Knorr-Cetina, 1983, pp. 120-126). This indexicality or contextuality (Hess, 1997, pp. 100-101; Knorr-Cetina, 1983, pp. 120-126), moreover, also emphasized the social interaction within science. The image of the traditional single scientist's interaction with the world was replaced with a focus on the scientist's interaction with both the world and his colleagues (Kvernbekk, 2002, pp. 68-69). Illustrated by Måseide's scientific discourse, a new dimension was added to the internal content of science: It implied that the representations of a phenomenon, such as the linguistic images in a scientific paper, were to be regarded as highly contextually determined (Hess, 1997, pp. 100-101, Måseide, 2006).

This contextuality is however one of the most questionable aspects of constructivist thought. Such high contextual dependency in the production of knowledge can be taken to make each scientist the definitive judge of what to consider as knowledge. This can result in considering reality as no more than what the individual perceives it to be. Science can therefore create multiple realities where no belief is any better than other beliefs (Kvernbekk, 2002, p. 71). The consequence is a relativism where no valid truths exist (though one should place such statements strictly only within radical constructivism). However, this undermining of any theory as potentially true

would then immediately refute itself (Hess, 1997, p. 18). Kvernbekk (2002, p. 73) asks why we should believe that the internal content of science is more or less completely determined by the context, when the scientists conducting these studies are themselves influenced by the very same sorts of contexts as the scientists they are examining?

The constructivist response to this critique was to point to the supporting aspects of the groups or networks of scientists. To avoid relativism the production of knowledge was emphasized to rely on the consensus within these groupings. One bases the appeal to consensus, however, on the phenomenon of infinite regress: The results of an experiment must be verified through endless repetition, unless some consensus is reached within the society or context in which it is taking place (Ibid, p. 72). According to Kvernbekk (p. 72), this argument has its source in Kant's idea that we do not have independent access to the unrepresented world and that absolute certainty is not possible to establish. However, within this way of thinking it is possible to establish a consensus within a discipline based on agreement within the group or network of scientists (pp. 71-72).

**The Picture-telling Story**

When the pre-given picture of scientific knowledge is considered, the picture-telling story also needs to be addressed. Through my deep-diving narrative, I now see that the modern scientific notion, which I obviously have operated within, that the objective truth of any given phenomenon is only to be presented in a scientific paper, reflects a simplified understanding, which undervalues the work that I put in, and the process I go through in my endeavors with a manuscript. It undermines the significance of the writing process, which I believe is more strenuous and comprises a bigger part of the scientific process than the picture-telling story implies. This notion however goes further, since it omits so much of the work done outside the

scientific “laboratory” from the representation of what science is: in a manner, it becomes the ultimate manifestation of the fact that the acting and thinking human subject is left out of the scientific story.

The importance of the writing process is something Johansen (1998) also emphasizes as he explains why he puts so much work into this part of the scientific work: It is not solely to be able to present an academic content; on the contrary, it is mainly to be able to acquire this content. He describes it as a knowledge-developing process where the content occurs along with the endeavor of formulation (Ibid). I do not just write down something I have thought about, or something I know all about, in advance. The thoughts, and what I ultimately present, can also occur because of the exertion of expression: the more work I put into giving expression to my thoughts, the more I am able to think about the topic under examination (Johansen, 2012, p. 15).

Writing can thus be considered a research tool, or a *thinking technology* (Johansen, 1998, p 21), and to write well is thus to be committed to the topic in such a manner that both the content of the thoughts and the linguistic expression stand out clearly (Ibid). As such, writing becomes a way of knowing, a method of inquiry and a way of finding out about ourselves and whatever topic we are working with (Richardson, 2003, p. 499). Based on the narrative it hence becomes clear that writing is not a simple, straightforward activity, producing a predetermined and transparent report of what is studied (Ibid, p. 499). The modern conception, giving the impression that the writing only occurs after the knowledge has been established, and that nothing significant happens while one is writing, is therefore quite inadequate (Johansen, 1998).

**The process of thinking**

Johansen further explores this part of the scientific work as he draws a distinction between, what he describes as, *spoken* and *thinking* languages, both with respect to the act of writing (Ibid). Although both kinds of languages have in common the exchange of opinions, what determines whether the writing amounts to literature is the will to really take the labor of writing seriously, and not simply write down what appears in front of us (Johansen, 2012, p. 18). Writing seriously is then again, exactly, to think, and to write ambitiously is thus to think ambitiously (Johansen, 1998). This ambitious thinking can be further equated with philosophical thinking, which has been referred to as a search for wisdom (Jørgensen, 2008, p. 10), which then again is a concept described as being in the possession of a universal perspective, a perspective that presupposes a conceptual reflection (Ibid, p. 9). However, the very starting point of wisdom, and what distinguishes this perspective from more classic metaphysics, is its closeness to experience (Ibid, p. 10).

The phenomenological character of philosophical reflection makes it possible for us to explore our immediate experiences. Often we stand in the middle of our experiences in a way that they are so obvious to us that we have become blind to what they really are in our life (Wolf, 2002, pp. 93-94). The task is to reach the things we perhaps already know but maybe do not have the language and concepts to articulate or define precisely. However, even though we have to remain within the experience as it is, we have to do this while still being oriented toward the universal. With this phenomenological-hermeneutical process, it is possible to emphasize the things we are deeply familiar with but have never really noticed. It is like finding out something we already know but still have not fully comprehended, and hence we try to break out of habitual thinking, exceeding the comfort zone of our prejudices by delving into them (Johansen, 2012, pp. 20-21, Jørgensen, 2008, p.

11). Wisdom hence becomes a search for insight we can find by reflection (Jørgensen, 2008, p. 11).

This openness, however, risks focusing too much on the particular, and in order to avoid losing the universal perspective, a high level of awareness is required (Ibid, p. 11). We understand the particular experience not only as an individual part, but also in connection to the whole. This perspective can be described as a lookout post where we are at a higher level from which we can reflect on our experiences without being dazzled by them (Ibid, p. 11). Only in this manner can we manage them as what they are: pre-understandings that have the potential to become true recognition, but have not yet. This hermeneutical process, with its movements back and forth between closeness and distance (Gadamer, 2003, pp. 33-44), is what makes it possible to move on different levels at the same time and, thus, to be able to relate both to the particular and the universal, in a manner that makes them reinforce each other. This elasticity makes it possible to combine knowledge and wisdom (Jørgensen, 2008, p. 86), and to me, this is an essential aspect of science. It is not only about the production of knowledge; it is also about placing the things we come to know in a larger and more holistic perspective.

**A Holistic View**

By these thoughts, I believe I am approaching some kind of new scientific basis: some kind of holistic epistemological view. This view can perhaps be described as something like a merging perspective that integrates insights from other and previous perspectives. The purpose is thus not to replace any of the other and previous thoughts. On the contrary, the aim is to fuse the strengths of the other theories (Johnson and Onwuegbuzie, 2004), bringing the best parts together into something which might lead to a more holistic cognition. This can be viewed as an extended version of triangulation, which is based on the logic that we can move

closer to obtaining the true picture if we take multiple measurements, using multiple methods or implementing multiple levels of analysis (Cox and Hassard, 2005). An example of this way of thinking is Wilber's (2007, pp. 59-84) quadrant model, which explains how every piece of knowledge can be understood on its own, as well as integrated into a more holistic view. To reach the entirety, various underlying levels are taken into consideration and different perspectives on the subject matter are acknowledged.

This entails, however, that it is not necessary to approach every scientific problem pluralistically. In the study described through the deep-diving narrative, for instance, elite female soccer players' aerobic performance ability was explored. Players were individually tested for maximal oxygen consumption and anaerobic threshold in the physiology laboratory. The aerobic ability of one player is, however, just one element of her total physical performance ability (others are strength, speed, etc.), which then again is just one element of her total ability as a soccer player (others are technical skills, tactical thinking, etc.). Further, one soccer player's total performance ability is only a fraction of the team's total performance ability, as there are eleven players. Another element to consider is that our measurements concern abilities related to soccer players' performances, but that they say nothing about the players' actual performances on the soccer pitch.

Furthermore, I do not claim that the way we assessed these players' endurance capacity was the only way to do so. Does this imply that our one-sided approach cannot be understood within this holistic view? I suggest that it can because I acknowledge that our findings are only pieces of something bigger. This is my point. Accepting this holistic view does not necessarily mean that every topic have to be approached interdisciplinary, but it means that the produced facts have to be interpreted within such a belief system. This further implies that it is not necessary

to stick with one methodological point of view. How we approach our research may change from time to time, and is dependent on the topic and question put to examination (Chong, 2003).

Nevertheless, this holistic science and knowledge view aims to integrate different perspectives from where to view the world. In my opinion, this has the potential to provide a turning point in the ontological/epistemological discourse. From a categorical, barrier-building and polarized focus on them and us, with a dismissive and disbelieving attitude toward any other view than our own, we can now turn to a more ethically and epistemologically sound point of view. A view where we can accept and acknowledge that the boxes, we term scientific knowledge and scientific practice, are supplied with more elements. Within this perspective, it becomes easier to appreciate other topics and other questions than the ones we are working with. We acknowledge that what we ask for is a result of the tradition and culture we are a part of; that it is related to our curiosity, our general interests and our desire, as humans, to understand whatever context we find ourselves situated in.

Within this way of thinking, the knowledge hierarchy ceases to exist, putting an end to the undermining of certain kinds of knowledge (Fossestøl, 2013, p. 61), because all kinds of knowledge are considered as contributing to seeing ever more clearly. The kind of knowledge deemed most important will hence always depend on what phenomenon we are looking at. This does not mean, however, that everything goes, and that we have to agree with every claim made in the name of science. From this ethically and epistemologically more holistic standpoint perhaps a more nuanced, respectful and open academically oriented discourse can arise. Different perspectives on the world can be accepted and acknowledged as having the potential to enhance and expand our horizon of understanding, rather than to impair it.

A question, though, is, how will this new holistic epistemological view look like, more specifically? I believe my practice still can be described as the exercise of some kind of scientific method, although as emphasized I need to supply, and ultimately then accept, more elements into this method box. In a paper from 2005, Grobstein gives a description of a more contemporary method for pursuing natural science, which he contrasts to, and represents as a critical perspective upon, the modern science´s linear scientific method. The paper provides many constructive thoughts, adding more to the box, that among other things aim to bring down the borders between science and the more general human culture. The paper also embraces a diversity in scientific conduct, and it is requested a more open-minded attitude towards different scientific perspectives. Furthermore, it also emphasizes that it is important to accept that science has a personal, call it human, element.

One may briefly summarize this more contemporary scientific method in the following manner: The classical hypothesis is replaced with a summary of observations, which then again provides predictions about future observations. The experiment is changed to making new observations to see if they match the predictions. If they do not, the predictions are falsified. However, if the observations match the predictions, it is only to be regarded as a truth in the sense that it is a summation of all observations made up to the present. Thus, a truth can never be finally verified, and must be considered as only provisional. The scientific process is hence a process of continual revision, in which scientific statements cannot be considered as more than tentative truths that reflect the human perspectives from which they arose and that become progressively less wrong (Ibid).

In my opinion this contemporary version of scientific conduct, however, does not take us very far beyond the modern science and knowledge view. I believe we are

still located within the modern science and knowledge view, at least within some post-positivistic thoughts, perhaps now in the direction of the theory of critical realism. Within this view, reality is believed to exist independent of science's knowledge of it (Miller and Tsang, 2010), and although it upholds the possibility of achieving truthful knowledge, it also highlights that it is my human limitations that impair my ability to reach any objective and universal knowledge (Ibid). There is nothing in the methods of science that guarantees success in arriving at an absolute truth. Consequently, every scientific knowledge claim and every scientific theory should be critically evaluated and tested through thorough empirical observations (Ibid).

At first glance, these thoughts may seem like indicating progress in how we envision contemporary natural science. Even though I acknowledge that it perhaps suggests something in the right direction, I believe we are still far from taking any vital steps. Although it is critical to modern science's craving for absolute certainty, and this critique is based on the thought that each observation or each perspective has both a personal and contextual element, these elements are only conceived of negatively. It inadvertently leans toward a kind of subjectivism, implying that this is something I as a scientist ought to free myself from in order to be in a position to come to objective and neutral knowledge of any subject matter. Another problem is its emphasis on the empirically observable hard facts of the world. This suggests a reductionism delimiting the scope of science and narrowing down what can be considered as real. Such reductionism perpetuates the belief that some knowledge claims that have arisen from the hard sciences are more truthful, and have more epistemological value, than knowledge claims that have arisen from the humanities.

In accepting this kind of realism, we also seem to have to accept the idea that on the other end of the implied epistemological scale, in the opposite direction from this

realism, it exists something resembling pure relativism. Furthermore, this provisional empiricism suggests that the next observable fact is able to falsify whatever theory or conceptions the scientist held in the first place (Popper, 2002, p. 10). This amounts to a skepticism of theory and of human thought and rationality in favor of the next observable fact detected, and, hence, is problematic. Additionally, although this view seems to accept rationality, it is in my opinion rationality only in a reduced form, as pure logic.

The objective reality that this scientific view believes to exist *out there* is perhaps then not a goal to attempt to attain because it would imply giving up my own human heritage, as well as implying that these truths are cut off from the context of which they are part. The desire to reach a neutral and objective understanding stripped of any particularities of human perspectives and contextual references would be the view from nowhere, and thus completely barren of human meaning. Heidegger contradicts this reducible objectivity by claiming that every concept has to be seen in light of a system of reference, and even that it is this contextual relation that makes the concept what it is (Ihde, 1993, p. 108). Furthermore, the aim of the scientific endeavor cannot be knowledge just for the sake of knowledge. It has to lead to some kind of human understanding, and everything we understand we interpret in view of something we already have understood. Hence, if I want to understand something, I have to bring myself, my pre-understanding, into play (Gadamer, 2003, 33-44). Consequently, this is what constitutes the very starting point of any new understanding. The completely objective scientific truth, cut free from its context and the individual subject who holds it, thus becomes something that exists only in a scientific vacuum, something comprised of no human value or meaning, thus becoming, well, meaningless.

Therefore, I do not think we have come much farther than the modern knowledge and science view enabled us to come. I do not believe we have reached any more clarity regarding how new knowledge is developed. However, in my opinion Polanyi can be a guide out of this deprivation. By examining his concepts of knowledge, of personal as well as objective knowledge, and his descriptions of the tacit dimensions in the process of knowing, I will try to show that we can take some substantial steps toward a better understanding of scientific conduct. I will try to show that it is possible to acknowledge an expanded way of considering objectivity where it is also possible to recognize the personal and contextual elements of scientists - not as something unfortunate - but as the ultimate starting point of any scientific endeavor, as well as a presupposition for the discovery and establishment of any new knowledge.

## Polanyi and the Act of Knowing

### The basis for his work

A question then arises: Where did we go wrong? Where did we begin to believe that our humanity would deprive us of the possibility for scientific truthful recognition? Where did we lose the human in the process of knowledge development? Where did we begin to distrust the human faculty of thinking, of upholding ideas and theories, which, according to the contemporary philosophy of science, natural sciences are willing to abandon whenever a new observable fact tells us to? According to Polanyi, we have to go back to the scientific revolution to understand how this view of science originated. As emphasized in the modern natural science and knowledge view, the scientific revolution was a turning point in the history of science. It has had a tremendous positive effect upon modern science as well as modern society in general. It created an understanding of humans, of science and of knowledge, which has been the preferred one up to the present day. However, we can wonder if we by our somewhat naïve confidence in these thoughts perhaps at

one point have let it go too far, and that this has contributed to some of the problems we still face within natural science, and from which we apparently have some difficulty freeing ourselves.

The primary problem with the scientific revolution, according to Polanyi, was Copernicus' discovery of the earth not being the center of the universe. In a symbolic, and I will believe not intended manner, this, in itself an exceptional scientific achievement, resulted in removing human beings from the central position in the universe. This manifested in some kind of idea that the perspective I as a scientist, or even as a human, ought to consider the world from, should be an objective and neutral point of view. Polanyi's counterargument was however that it is impossible for humans to step outside themselves to view the universe, and that any efforts to reject this obvious truth, are almost absurd (Polanyi, 1958a, pp. 1-2). Secondly, as a consequence of the revolution, there emerged a conception that the ultimate reality was composed of material substances such as atomic particles, and that it was possible to come to some kind of absolute, certain and universal knowledge about those substances. This reductionism went so far as to suggest that even human beings are nothing more than a somewhat random collection of atoms, devoid of any purpose or meaning (Polanyi, 1965b). This led to a desire within modern science to explain everything within the frame of natural, or mechanical, laws. It also created a disbelief in the very existence of immaterial things, things that could not be observed empirically, or discovered by pure logic. Furthermore, alongside these problems, Cartesian doubt also arose and nourished this skepticism toward our self and our humanity (Bergo and Hide, 2005, p. 15, Merleau-Ponty, 2008, pp. 32-33).

Nevertheless, within this mechanistic belief system, the modern natural scientist and his search for universal knowledge has become an ideal. Observation and

registration of the hard facts of reality, within a dualistic or distanced framework, have become the essence of scientific practice. Furthermore, the worship of observable facts has made the scientist willing to uphold theories only temporarily. Whenever a new observation contradicts a theory, idea or thought I may have held up to that point, I must be prepared to drop it immediately in favor of the new observation (Polanyi, 1958a, pp. 13-14). Furthermore, and even more peculiar, if a theory cannot be tested by observation as it is, I should attempt to revise it with the aim of making its predictions compatible with measurable quantities. Polanyi also highlighted that although the modern scientist is excellent at performing according to whatever methods he applies in his endeavor to observe the facts of today, he would be perplexed in his search for something worthy of knowing (Polanyi, 1965b).

After all, the things that are most interesting to gain knowledge about are things "that are seen, felt, heard and smelt" (Ibid, p. 13), things that in one way or another affect us as humans and provide something meaningful to humanity, which is something the modern mechanical science view fails to accomplish on its own. This is because gaining such knowledge requires the action of sentient human beings, human beings capable of perceiving, appraising and understanding the magnitude of information that our senses continually receive. The first thought following this might be that this has nothing to do with science. This, however, is a misconception, because Polanyi did not want us to abandon all striving for scientific knowledge worthy of being acknowledged as objective and to some extent even universal knowledge. Rather he wanted to show that it is possible to come to such knowledge of even immaterial levels of reality and thereby re-establish a scientific acceptance of higher forms of existence (Ibid, p. 13).

**Stratified ontology**

The first example Polanyi used to emphasize his thinking was the clock. He pointed out that the mechanical science view on its own is as unable to tell time, just as the chemical testing of a printed page of text is unable to give information about its content (Ibid, pp. 13-14). By this, Polanyi showed that every machine, like the clock, and even any machine-like system, like living beings, consists of at least two levels. The lower level consists of isolated parts controlled by whatever laws or principles apply at that specific level, while the upper level embodies the functional principle of the system as a whole, making visible the united meaning of the parts (Ibid, pp. 13-14). This was not, however, to say that material things, on its own, were of no special importance. Even the smallest substances of nature are of great significance, but the meaning lies essentially in higher levels, where the isolated parts reach a united and functional meaning. An example would be the physiological data, such as blood lactate, that I have examined in my research. On its own, any blood lactate value can tell us almost nothing. It is only when it is contextualized, when it is considered in relation to its holistic functionality that its practical applicability becomes visible and it acquires meaning.

Furthermore, as we perhaps begin to understand, this stratified ontology does not have to consist of only two levels. Again, as shown previously with the physiological data on soccer players, there can be several levels, and even series of levels, that together form a hierarchy of rising levels of existence (Polanyi, 1961). When living human beings are put under examination, as these soccer players were, the complexity of this hierarchy becomes especially visible. Furthermore, as the meaning is found in the comprehensive entities which the parts jointly form, this also implies that the meaning becomes increasingly rich at each successive level and that it reaches its most complete form at the very top. Hence, it is clear that the goal of science according to most contemporary views of natural science, upholding a

belief in an objectivity corresponding to a reality in its most reducible form, is a mistaken target. As Polanyi (1965b, p. 15) emphasized:

> What is most tangible has the least meaning and it is perverse then to identify the tangible with the real. For to regard a meaningless substratum as the ultimate reality of all things must lead to the conclusion that all things are meaningless. And we can avoid this conclusion only if we acknowledge instead that deepest reality is possessed by higher things that are least tangible.

**The power of integration**

When I try to come to knowledge about any comprehensive entity at an upper level, it thus becomes clear that I have to rely on the elements of the lower levels as clues. Inspired by Gestalt psychology, and hence using sensory perception as an analogy to the act of coming to knowledge about any comprehensive entity, Polanyi furthermore emphasized that to be able to see reality as it is, I have to attempt to integrate information from the whole area of my vision (Polanyi, 1961). Consequently, as I move upwards in the ascending hierarchy of this stratified ontology, the number of clues I have to include, as well as the complexity between them, increases. Some, perhaps even most, of the clues on which I rely come from within my own body. When I observe an object like a pen, I do so by performing intelligent operations wherein sensory inputs are integrated together with internal reactions (Polanyi, 1965b). However, when my perspective during observation changes, whether due to an adjustment of angle or lighting or perhaps a rotation of the pen, the clues on which I rely, may also change. Still, the pen remains to me an unchanged object (Ibid). If I, on the contrary, was to manipulate my vision, the scenario would alter. Polanyi describes how, if I were to look at the same pen through a pinhole in a sheet of paper, some of the periphery clues on which I rely to

form the image are lost, which causes some of the pen's solidity as an object to become lost to me as well (Ibid).

Furthermore, to be able to identify the whole at all requires that I reduce my awareness of the clues constituting the whole. If I focus my attention on any given clue, and not on the whole, to which it is contributing, my ability to grasp the joint meaning becomes reduced. When what is the holistic object at one level becomes a clue at a higher level, this can be challenging. This becomes even more visible when looking closer at any skillful performance that I am to conduct. For example, when conducting high-intensity experiments with humans in the physiology laboratory, if I were primarily to direct my attention on the next step in the procedure or on a piece of equipment, rather than on the subject running on the treadmill, the very act might be paralyzed.

Nevertheless, as has been seen, some of the clues exist only in my peripheral vision; some are not known to me, and some are perhaps not possible to specify. In a sense, I am only aware of them as they make it possible for me to come to knowledge of an object or to perform any skill. By this, I understand that I do not attend to these clues, but that I rely on my "subsidiary awareness of them for attending to the coherent entity to which they contribute" (Polanyi, 1965b, p. 17). This can be understood as a tacit reliance on my awareness of particulars, which are fused and formed into a meaningful way of perceiving them. Polanyi's primary example of this is the ability to recognize physiognomy, such as a human face, by the integration of its particulars, while being unable to specify the particulars themselves (Polanyi, 1966, p. 6). In the laboratory, such as with Anne, it happens often that I just see something. I place my eyes on the computer screen, where a myriad of numbers and data is displayed; I cast a short look at the person running on the treadmill, and then something just appears in front of me. Perhaps something

making sense and which I know is, as it ought to be, or perhaps the opposite, something that does not make sense and which does not seem to be as it should. However, such incidents occur most often without me being able explicitly to describe what I see. It feels like a hunch or like a form of intuition. As I now understand it though, it is something else – something more.

**Knowing and understanding**

This tacit integration is an interpretive exertion. As seen, it is as if I understand something, but am unable, at least to some extent, to explain how I do so. It is exactly in the exercise of comprehension that the organization of tacit knowledge best becomes visible. What is interesting, then, is that this faculty of comprehension is one of the very things that the mechanical science view has refused to acknowledge. It has denied the possibility of the existence of comprehensive entities distinct from their particulars. For Polanyi, however, things that are not understood can neither be claimed to be known: Comprehension is never absent in the process of knowing and is in fact, to him, "the ultimate sanction of any act of knowing" (Polanyi, 1961, p. 4). Based on this, another clarification also emerges, which, although not presenting anything really new is for me an important reminder. That knowledge is linked to understanding emphasizes so clearly that knowledge is not something static. Polanyi hence claimed that it would be better described as a process of knowing.

To exemplify this process, Polanyi (1958a) at one point describes it in relation to the way a medical student gradually learns how to diagnose pulmonary diseases based on X-rays. Initially, the student is only capable of seeing the basic anatomic structures of the radiogram, which naturally enough can be spotted as shadows on a light background. Gradually, however, he will be able to leave these most prominent elements and begin to see the lungs more holistically. Eventually an understanding

will arise where the student becomes able to rely on an increasingly vast number of clues, together making up the joint meaning of the radiogram. Then, "a rich panorama of significant details will be revealed to him: of physiological variations and pathological changes, of scars, of chronic infections and signs of acute disease. He has entered a new world" (p. 106).

**In-dwelling**

Within this conception of knowing, it has become clear that I know things by relying on my awareness of them in order to attend to something else. My reliance upon these clues is then again something I gradually learn to do. To a great extent, my knowledge of these clues is virtually entirely based upon the fact that I rely on them when I attend to another thing. I have also mentioned that some of these clues are within my own body. In a sense, my body is a collection of clues that I rely on when attending to something else. Furthermore, I rarely identify my body as an external object. However, I have gradually learned to rely on it when I observe, or operate within, the external world. Thus, the way I have come to know my body is exactly through the attendance to something else. The knowledge that I have, and continue to develop, about my body, is acquired by living in it. This leads us to Polanyi's (1965b) concept, of this subsidiary knowledge, as a knowledge I have of my body by dwelling in it.

Every new clue that I come to rely on in any circumstance is exactly an enrichment of this bodily reliance, which he describes as an "extension of our bodily existence to include things outside it" (Polanyi, 1961, p. 6), and illustrates with the example of a hand-held tool. In use, the tool becomes an extension of the person's hand, but the person cannot express how he uses the tool any more than he can express how he uses his hand (Polanyi, 1966, p. 13). Hence, when we come to knowledge or understanding about something new, or become capable of performing a new skill,

we become able to integrate, or internalize, more clues by this very act. It is an expansion of our horizon of understanding. Every step of comprehension involves an expansion of our self into a new dwelling place (Polanyi, 1961).

The structure of this form of tacit knowing can be described as a triad consisting of the subsidiary particulars, the focal target and the knower, who links the first to the second (Zhenhua, 2006, p. 187). The way we understand any external objects is through some efforts inside our body, and from these internalized processes, we attend to the qualities of these external objects. This may be understood as a conversion of our bodily experiences into the understanding of things outside, and these processes are to some extent present in all processes of knowing (Polanyi, 1966, pp. 13-14). These bodily experiences, moreover, can be understood in the direction of the hermeneutical pre-understanding, which forms the horizon of understanding from which we view the world. Based on inherent, embodied and internalized knowledge, our body becomes the ultimate faculty for all external knowledge (Ibid, pp. 15-17). Hence, we always attend to the world, more or less intelligently, from our body (Ibid, pp. 15-17).

This way of thinking is present at all levels of Polanyi's stratified ontology. In the same way that I have gradually learned to integrate information from a variety of sources into my decision-making in the laboratory, I can also attend to other human beings' minds. By the act of empathizing, it is possible for me to come to knowledge about another person's mind by in-dwelling in its expressions (Polanyi, 1961). For this, however, I have to create a special, intimate relation with the person to whom I am attending. I have to create what Polanyi describes as a life-sharing partnership based on equality with the person (Polanyi, 1965b). Furthermore, in this way of thinking, the categorical differences between the way we know tangible and intangible things become almost invisible. They are left, not as fundamentally

different kinds of knowledge, but rather different variations of the same kind of knowledge. There may be different compositions, amounts and levels of the ingredients that make up the sum, but the sum, whatever it is, is the same kind of sum.

Within this hierarchy, the amount of information, the number of clues and the overall complexity increases with each level. In a sense the background or the context for the object, to which I attend, becomes less static and more difficult to control for. Hence, my abilities, cognitively to process information, to see patterns and connections, as well as my intelligent powers to interpret, judge and comprehend, become especially important, the higher up in this hierarchy I move. Furthermore, an ethical knowledge view, such as this holistic view I have emphasized, is vital to establishing the required life-sharing partnership with the person I am attending to, because if I am to understand another human being, I have to acknowledge him for what he is. I have to approach him open-mindedly, to try to assume his perspective, to build a bridge from me to him. In a sense, our horizons of understanding have to melt together (Gadamer, 2003, pp. 33-44).

The modern natural scientific view of objectivity, wherein the ultimate reality corresponds to reductionism, is then only to be understood as more complete or finished, compared to the more idiosyncratic sciences, in that there are fewer clues and less complexity involved in the act of comprehension. The act of comprehension is, however, the same. The attempt to understand a physical phenomenon of the world requires the same kind of empathic immersion in the object to which I attend (Wackerhausen, 1997), as the attempt to understand another human being. It is just that the higher the level, the deeper this immersion in the subject matter must be (Polanyi, 1958a, p. 403). The problem is that the modern science view has reduced

our understanding of the process of knowing to methodological rigidity and pure logic. In my opinion, there is more to the natural scientific practice than this implies.

**Two kinds of knowledge**

*Personal and objective*

To sum up then, the process of knowing is basically the same, independently of what is to be known, and although variations exist, different kinds of knowledge have the same basic constituents. The two main ingredients that form knowledge as a whole are, as described, the subsidiary clues and the united entity that the clues together constitute. The clues are, according to Polanyi, the personal element of knowledge, while the joint entity is the objective element of knowledge (Polanyi, 1961). Hence, it becomes clear that Polanyi believed human knowledge to be of two varieties: an objective one resembling the modern view, which may be described as explicitly expressible knowledge, and a personal, not completely linguistically expressible, embodied and action-oriented knowledge, consistent with a person's ability in knowing and action (Polanyi, 1958b, p. 12). Thus personal knowledge is, as also previously described, primarily tacit knowledge. As we have seen that these tacit processes contribute to every act of knowing, the personal element is also present in all processes of knowing.

There are two dimensions of tacit knowledge, above also briefly mentioned. The first dimension, referred to as tacit knowledge in the strong sense, consists of skills or crafts, and is often referred to as *know-how* (Ryle, 2000, pp. 26-29). It is something which is not possible to express verbally, and hence discloses a gap between our ability to execute any action and our ability to express verbally what we do (Zhenhua, 2003-2004). The second dimension, tacit knowledge in the weaker sense, is a more cognitive one, called connoisseurship, which consists of deeply integrated beliefs, assumptions, ideals and mental representations that often are

taken for granted and which shape the way we perceive the world (Nonaka and Konno, 1998). Within this dimension, we find knowledge that is not verbally inexpressible, but rather something, it is, perhaps, necessary to keep within our subsidiary awareness in order to maintain our focus on the target to which we aim to attend. Further, it can also be something we understand, but that we are not capable of giving complete and precise expression to. However, this does not imply that it is not verbally expressible in principle (Zhenhua, 2003-2004).

Nevertheless, tacit knowledge is the basis of all explicit knowledge. All explicit knowledge has a tacit root and, as described, tacit powers are the ultimate faculty through which humans acquire and hold all knowledge (Polanyi, 1966, pp. 15-16). Even for the most objective and explicit knowledge, we have to rely on tacitly comprehending it to get hold of the meaning of any statement, and this process is a process based on tacit powers of the knower (Zhenhua, 2003-2004). Whatever explicit data coming out of my scientific conduct, such as the level of blood-lactate, has no meaning before I have placed it in its context, where I view it in light of some background. In this regard, I might highlight that even Einstein emphasized that the physical concepts science deals with are creations of the mind, and not something fully determined by the external world (Einstein & Infeld, 1938, in Grobstein, 2005, p. 7). The way any explicit statement has to be tacitly comprehended was also something Wittgenstein highlighted. He stated that the meaning of any concept was found in the way it was used (Wittgenstein, 1969/2005, § 61). In the introduction to the Norwegian translation of his book *On Certainty*, Bergo and Hide (2005, pp. 32-33) offer the example of the poor student who informs his parents that he has bought a car and the parents reply, “Car!?” They then turn the scenario around: This time the parents inform the poor student that they have bought him a car and he replies, “Car!?” The sentences expressed are the same, even the linguistic signs are the same, yet the meanings of the two statements are significantly different, and

can only be understood, if the context is equally understood. Polanyi therefore argued that it is impossible to acknowledge the existence of a completely explicit knowledge (Zhenhua, 2003-2004), claiming that despite the fact that language expands human intelligence well beyond the domain of tacit knowledge, the way we use language remains tacit (Ibid). Even when I push my horizon of explicit knowledge forward, this will require a renewal of the linguistic framework that I hold; this very act is only possible if I can go beyond the exact framework that I possess at this very moment (Ibid).

Completely explicit knowledge, the previously described modern ideal of perfect knowledge, therefore does not exist. Explicit knowledge is better understood as the tip of the iceberg surfacing the water, which strongly depends on the tacit fundament below the surface. What is visible is just a fraction of the whole. Any knowledge expressed is thus never equivalent with the knowledge of the person expressing it. I believe that we should consider any verbal or written explicit and objective knowledge statement as an expression of our knowledge and not as the knowledge itself, in the same sense as any expression of our skills is just an expression of these skills and not the skills per se. The degree of correspondence between the expression and the actual knowledge, or skills, can of course vary, and is to some extent dependent on the depth and complexity of what we want to express.

To some extent, this iceberg can also serve as a metaphor for the relationship between mind and body, where we can acknowledge our body as an essential part of any act of knowing. Polanyi was critical of the Cartesian legacy, which upholds a dualism between the two and where the mind had a superior role, explicitly controlling the body, as if the relation between them were only a one-way street. Think of how the word “I,” which equals the mind, refers to something with a

disembodied existence, yet situated within our body (Bergo & Hide, 2005, p. 19). However, neither did Polanyi (1965a) agree with the opposite view, exemplified by Ryle's (2000, pp. 49-57) description of the workings of the body and the workings of the mind as amounting to the same thing. Polanyi (1965a) believed in the superiority of the mind, but he believed its relationship to the body to be more like a two-way street, where the interaction between them also, contrary to Cartesian explicit interaction, is managed by the logic of tacit knowing.

As we understand, and as Polanyi so clearly shows, this does not mean that explicit objective knowledge is not important. As a scientist, I truly believe that scientific knowledge has an epistemological precedence in that it possesses the potential to achieve a particular truthfulness. Yet the process of knowing is an active, comprehensive process in which I tacitly rely on a set of particulars in the shape of a whole. According to Nonaka and Konno (1998), any knowledge development can be described as a spiraling process of interactions between explicit and tacit knowledge. In all acts of knowing, there is a requirement that I am able to bring my personal participation into this act. As previously emphasized, this personal participation should not be equated with subjectivism, which is unable to take me beyond my own feelings and assumptions, my own pre-understanding. The personal participation is not a flaw or something I should try to get rid of, but rather a vital component of any process of knowing. This way of thinking surpasses subjectivism because it acknowledges, and aims for achieving, exterior standards or ideals (Polanyi, 1958a, Preface). Hence, it cannot be understood as a random act but must be seen as a responsible act demanding universal validity (Ibid). This personal component enables the development of any new scientific knowledge. Thus, it bridges the disjunction between subjectivity and objectivity and opens the door for me to transcend my subjectivity by attempting to fulfill my personal responsibilities to universal standards (Polanyi, 1958a, p. 27, Husserl, 1997, p. 178).

In a sense, it replaces the anchoring of objective knowledge in pure empiricism or pure logic with a more ambitious anchoring in reason. My own abilities to think, to appraise, to judge, to reflect, to interpret and to understand become essential elements in any process of knowing. My ability to frame ideas or theories that deserve respect in their "own right, by their very rationality" (Polanyi, 1958a, p. 3), or my ability to grasp the essence and to see a rationality within whatever phenomenon I am looking at, becomes vital in itself. Polanyi describes this inner rationality as an inherent quality, something worthy of reaching universal acceptance, and something that has objective standing (Ibid, pp. 2-3). What is also interesting is that, according to Polanyi (Ibid, p. 3), to some extent it is by the predictive powers of an idea or a scientific theory, where the implications are not fully known, that objectivity in its deepest form is ascribed to it.

**Expanding my horizon**

This is not, however, a process of certainty. Any advancement in understanding is moved and guided by my power to see the presence of comprehensive entities behind yet incomprehensible clues. Reaching these hidden meanings can only be achieved by my active foreknowledge of this unknown, but yet accessible, reality. After all, my knowledge is no more than an intimation of the external reality, and in which directions this reality might develop I can never really know for certain (Polanyi, 1961). Any process of knowing hence becomes a pursuit of hidden meanings, which can only be approached by trusting my own intimations of them. Again, this personal aspect of the act of knowing transcends subjectivism, as it is not something I should strive to escape, like a bias, but rather the ultimate standpoint from which it is possible for me to know or to understand anything at all. In fact, it is the only standpoint possible for me to take when I view the world. It is not, nevertheless, a static standpoint. It constitutes my horizon of understanding and it

has the potential for continual expansion. The more clues, the more perspectives I can internalize, or at least take into account, in any act of knowing, the more I can see. However, this developing process requires that I am willing to self-transcend, and that I engage in this process, intrinsically motivated for this transcendence (Ibid). Furthermore, this inner drive enabling me to acquire new understanding must never be lost, but merely reduced when I come to hold new knowledge established by this drive. In fact, it is what makes it possible for me further to develop my understanding within the frames of my own ideas or theories. Every expansion of my horizon of understanding is thus a source for the creation of ever more indications of the world.

To embark on such uncertain scientific explorations demands human qualities of the deepest kind: human qualities, or powers, that we often have suppressed. Polanyi thought of us humans as unprecedented, but in need of restoring the balance of our cognitive powers. The higher power, making it possible for me to come to knowledge beyond what can be demonstrated by observation or proved by logic, is belief (Polanyi, 1958a, p. 280). In the pursuit of intellectual excellence, in the search for comprehensive entities hidden behind still incomprehensible clues, belief might be my best guide. With belief, Polanyi believes we can recognize and restore our reliance on our own thinking and appraisal as the supreme authority of all intelligent performance (Ibid, p. 279). Paradoxically, the modern world has condemned belief to such an extent that humans have renounced their own ability to uphold any explicit statement as their own belief. We can, however, again begin to acknowledge belief as the underlying source of all knowledge and that every intelligent operation, every process of knowing, can only be accomplished within such an impetus and such a trustful framework (Ibid, pp. 280-281).

My whole, unified self is hence placed at the center of my scientific activity, as in my previous description of myself as the most determining element of my scientific conduct. This again opens up another vulnerability and diversity in my conduct. It offers a view of the natural scientist, perhaps resurrects the natural scientist, as a passionate and accountable human being capable of diving into his scientific conduct with a human drive and a personal appraisal of his doings (Polanyi, 1958a, p. 26). It opens the door to the human personality as a whole, and introduces us to the unity of the sentient, creative and responsible life of human concerns (Zhenhua, 2006, p. 189). It presents us to the idea of natural science as a human practice in its richest form.

## Science as a Human Practice: Adding more to the picture

### Human judgement in a variable context

I am now beginning to understand that when I began this reflective journey to try better to understand my conduct, as a natural scientist, I did so exactly from a natural scientist´s point of view. I now, however, understand that it is more to science than what I initially believed and that the picture of my scientific practice can be further nuanced. One of the most defining elements of my scientific practice, as previously emphasized, is this problem-solving activity where problems are spotted, possible solutions are deliberated about, judgements made, and which then lastly becomes visible through the specific actions that I exert. If this activity was explored from a modern scientific point of view alone, any problem or challenge I meet is assumed solved either by rules of conduct or by formulas where the right thing to do is based on mechanical computations (Schwartz and Sharpe, 2006). There are not many things I do, though, in regards to laboratory work, statistical work or anything else, that come down to following some kind of fixed or programmed plans of action. It is not as if a switch is just, in a passive manner, turned on and then something happens on its own.

Smith (1999) writes about how the understanding of a modern practitioner, such as a scientist, within the modern science and knowledge view, has become reduced to some kind of core technology of what he or she does. Smith (Ibid) further equates the modern practitioner with a kind of primitive machine conducting rigid procedures and upholding no more than predetermined and established competencies aimed to remove all possibilities for making errors. The behavior of the practitioner and the predefined effect of this behavior are then supposedly linked together with sufficient scientific glue to avoid any pitfalls (Ibid). These procedures or competencies are however not up for the task alone, they do not tell me exactly what to do, in a specific situation, at the very moment I have to act. Furthermore, the problems or challenges that I meet in my practice can change from day to day, and there is no such thing as a prescription or a rule that in every occasion will guide me to the correct choice of action.

Behind every practical action the scientist exercises, it is hence a complexity and variability that transcends what this conduct is believed to consist of on the modern science view. The scientist needs to be capable of adapting to, improvising within and reacting appropriately to, a somewhat unpredictable and shifting environment (Nonaka and Toyama, 2007). As was the case with Anne, one has to figure out the right action for each case, every time (Fossestøl, 2013, p. 58). According to Fossestøl (Ibid, p. 59), the essence of making good actions in this complex practice is the exercise of discernment. A prerequisite for good discernment is then again that some kind of perceptiveness is present: that the scientist is flexible, attentive, alert and sensitive (Smith, 1999): that he is fully present in the actual situation at hand. As shown by Polanyi, the scientist has to be able to see what the problem is about, and for this, there are numerous sources that continuously have to be taken into consideration. It is about understanding the specific situation in an insightful way,

enabling precise decisions and subsequently good actions. The exercise of good actions then becomes a comprehensive capacity dependent on thorough considerations upon what needs to be done right now. Furthermore, when it comes to any choice of human action there are always human values in play. Each consideration about which actions to be exerted, consequently possesses an ethical dimension as well. In my opinion, further to explore these vital parts of the scientific practice, the concept of phronesis, presented by Aristotle in his virtue ethics, can serve as an appropriate and holistic framework for understanding.

**Aristotle and Phronesis**

The term "phronesis", we may today most precisely translate as some kind of "prudence". One understands it as referring to the ability to determine and undertake the best action, accounting for both contextual circumstances as well as the specific situation at hand (Aristotle, 1999, p. 118). According to Halverson (2004), it is as much a way of knowing as a kind of knowledge: it is a high quality tacit and embodied way of knowledge/knowing acquired from practical experience, and finally expressed through specific actions, as individuals *size up* a situation and develop and perform a proper plan of action. One can understand it as a guide in regards to identification of problems, and furthermore as an incorporating force of "apperception, judgment, choice, planning and action in a single continuous arc" (Ibid, p. 9). The outcome of this process, the performed action, is then something, as previously mentioned, that cannot be predefined. As long as we are dealing with human actions within any human context, the preferable action to perform is something the practitioner has to develop an eye for in every specific situation he faces (Aristotle, 1999, p. 33). As we understand it though, the aim is not to come to any general conclusions about which rules, procedures or techniques that are applicable for all circumstances, but to adjust knowledge to the specificity of the local conditions.

The universal perspective is however not set aside within the concept of phronesis. Guidelines and procedures of various types are an absolute requirement in natural science. In fact, it is what provides the scientist with the necessary opportunity to exercise phronesis where it really matters. According to O'Neil (1993, in Smith, 1999) a classic mistake by defenders of phronesis is to set it in opposition to some kind of scientific logic. In many situations phronesis cannot, however, be exercised very well without general procedures (Smith, 1999). Actually, in regards to my practical work, I believe it is perhaps best placed exactly in the open room of fitting principles or rules into particulars (Halverson, 2004). For this matter, the phronetic judgement is a judgement to which principle or rule to follow, or if to follow it at all. In a way, phronesis therefore becomes some kind of uniting force of all the standards, rules, procedures and protocols I follow in my practice. Like a mediator of the universal and the particular where it is not enough to know the general elements of the practice but where I also need to know how to apply them in every specific situation.

To be able to mediate or harmonize universal knowledge and its application to the particular situation, the essence of this particular situation, as seen by Polanyi, has to be grasped. To Nonaka and Toyama (2007), this grasping is described as a capacity to recognize a situation and understand what it requires, like a "continuous interaction between subjective insights and objective knowledge to identity the optimal way to behave" (p. 383). Honda (the founder of the motor company Honda), also emphasized the need to, what he called, *cross-pollinate* the subjective insights with objective knowledge as he said, "Action without philosophy is a lethal weapon; philosophy without action is meaningless" (Honda, 1963, in Nonaka and Toyama, 2007, p. 383). This bridging between the particular and the universal is to think on a deeper and more complex level. Different perspectives need to be accounted for,

and to do so, it is necessary to be able to relate to, and even to unify and harmonize opposites. We have to be able to see both the forest and the trees, at the same time, and in this traversing we even have to try to link the particular to what Nonaka and Toyama (2007) describes as a macro historical context.

Nevertheless, although the particular and the universal comes together to form the judgement, it is the former, which is the most important, and, which constitutes the very starting point for the determination of the best act. What the best thing to do is, when it comes down to any act within my practice, cannot, as described, be known with absolute certainty in advance, but I can have some assumptions about it (Aristotle, 1999, p. 115). These assumptions are based precisely on the ability to tacitly grasp and integrate the particulars into a holistic understanding. The assumptions we have are then again a result of all the similar situations and episodes we previously have met and which now come together as a guiding force enabling us to see the nuances in the new situations we face. Based on knowledge of the particular facts acquired through an extended period of experience, we gradually become able to anticipate, or to have some form of foresight, about something unclear which is about to happen (Ibid, p. 119). This makes it possible to see the world more accurately.

The number of particulars, clues or perspectives, which have to be brought together into a judgement can, thus, be diverse and varying. What is also clear is that we cannot know for sure that we are able to see all the clues of relevance in any given situation. Hence, the judgements made are not necessarily right or wrong; it is more as if they can be considered more or less good or bad. This implies that the ability to make a phronetic judgment is not an all or nothing affair, but more to which degree we do so. There will always be some kind of contemplating where we compare the assumptions we hold with what will happen, and where we are weighing the

different alternatives against the goal, for which we are aiming. For my part, I can hope that I am able to come to the most correct conclusion when facing any problem in my practice, but at the end, I am not guaranteed anything at all. However, my odds can, as highlighted above, improve by learning from experience. Schwartz and Sharpe (2006) emphasizes that we can become practically wiser by confronting difficult situations where we use our judgment to decide what to do, then carrying out the act and subsequently receiving feedback of what we have done. To be at all willing to enter such situations requires that I am committed, interested and engaged in what I do. Figuratively and non-figuratively, I have to situate myself in a dynamic learning context, where we create knowledge, put it to use, and share it with each other; and where I can see myself in relation to others and accept the views of others (Nonaka and Toyama, 2007). Hence, if I want to develop my phronetic judgmental ability, I have to be interested in coming in direct experience with the forefront, to where the actions happens, to the place Nonaka and Toyama (Ibid, pp. 376; 381) describes as *ba: a shared context in motion*. First by this willingness is it possible to transcend my own limited perspective and hence to develop my assumptions towards more completeness.

**A virtuous act**

So, if a scientist holds this willingness to self-transcendence, in what course of action ought his or her pursuit to be directed? What should be the target towards which the efforts are aimed? To Aristotle it is all about something good. In the search for the best action to realize, the *phronimos* is capable of contemplating well about what is the good action at the very moment, in the very situation, he faces. The good is considered primarily in relation to the individual who acts, but it needs also to be seen in the context of what is good for humans in general (Aristotle, 1999, p. 115). Every decision and every action exerted within a phronetic active human life is therefore directed towards something possessing a sort of universal goodness.

According to Resnik (1998, p. 31), one of the primary features of the scientific enterprise is exactly the aim to achieve common goals within a larger social environment. It is then, again, my responsibility, as a scientist, to work to achieve these socially valued goals, and furthermore, something with which my entire conduct has to be in accordance. In this context, a question suddenly appears in my mind: how many people have read these scientific papers of mine? Although there was an intention to disseminate my results to a broader audience at the beginning of my work, it seems as if it stopped at some point: As if I became most concerned with playing this scientific publication game, and thus that I chose just to relate to this closed scientific forum.

It is, however, exactly in the objective of reaching this common good we find the very starting point of any phronetic act. This intention – we may call it the major or minor premise within Aristotle's (1999, pp. 111-112) practical syllogism - does not only function as the crucial first step in regards to any specific action, as for example, that I apply in the laboratory. It is also, more generally, what have driven me into the different scientific projects I have conducted. It is something I have desired to find out, a knowledge-gap, something I did not understand and that eventually formed the very purposes of the different projects, now completed. Through this, we also realize that, what is good, the right end to aim for, relates to desire, and that the *phronimos* acts right as the right thing to do emerges for him: he sees what is right, and he desires to achieve it (Ibid, p. 48).

Looking at this in a more general perspective it becomes clear to me that I have always had a desire for learning, for understanding, for developing and for the mastery of whatever activities, operations or functions I was to exercise. In me as a scientist, this desire for mastery is hence not only manifested in the pursuit of enhanced knowledge of whatever subject-matter that I have worked with, or in

regards to any scientific study which I have embarked upon; it is also manifested in my whole developmental process as a professional practitioner. As phronesis corresponds to a kind of capability in whatever life-world the practitioner aim to act within (Ibid, p. 11), this desire for mastery can thus be understood exactly as a desire to become capable within the lifeworld that science is: To master the rules of conduct. However, as we have seen, each mean exercised with the aim of realizing something personally good, even my more or less general development, also implies the realization of something corresponding to a kind of common good. To avoid being stuck in a vicious circle of subjectivism, unable to break free from my own pre-understandings or prejudices, or to avoid science ending up in a deadlock of dogmatic assumptions, everything I do within the name of science ought to be aimed towards a true and reasonable concept about what is good for humans in general. Hence, the social assignment that science has implies that what I do as a scientist must provide meaning or some kind of usefulness to society. Again, as previously described with use of Polanyi's thoughts, this way of thinking surpasses sheer subjectivism because it recognizes, as well as aims for realizing, exterior values or ideals. This implies that my personal goals and these exterior goals should merge, and that I should aim any actions exerted, and even my developmental process as a scientist, towards the fulfilment of my personal responsibilities to universal standards.

The way the *phronimos* understands correctly what is good, is due to a human virtue, consisting in an attitude that enables us to find the right end to aim for in our active life (Aristotle, 1999, p. 30). What is good is then something in between too much and too little, and our virtues enable us to avoid extremes by finding the midway between those extremes. Our human virtues hence become this middle way in regards to the exercise of our functions, whatever it might be (Ibid, p. 30). This is the essence of Aristotle's concept of the Golden Mean. It helps us to think

*both this and that,* and not *either or*, or in other words, it helps us "to harmonize and synthesize contradictions associated with human nature" (Iizuka, 2003, in Nonaka and Toyama, 2007, p. 384). It is however not a mean in an arithmetically sense, but more to be considered as what feels like the middle way in the specific situation in which we humans find ourselves (Aristotle, 1999, p. 30). A virtuous act is then not an easy task to perform, because "to feel these things when one should, in the right situations, for the right persons, of the right reasons" (Ibid, p. 31), is difficult to accomplish. Hence, such acts are also "rare, praiseworthy and noble" (Ibid, p. 37).

In regards to the practical life of human concern, it is our moral virtues that ensure the right end to aim for, and phronesis that ensures the right means to accomplish it. Our moral virtues and phronesis are hence mutually complementary and their balanced combination secures the fulfilment of any human action. Aristotle (Ibid, p. 115) even takes it farther by claiming that the different virtues and phronesis even imply each other. This is also agreed to by Shulman (2007, p. 561), who expresses that "a practical judgement is always an expression of value as it ends up with a choice of actions in a context of uncertainty". Phronesis thus becomes, above all, a form of moral knowledge that guides the scientist in making this choice. Consequently, it is rather my human character, as a whole, that is at stake, when I make any particular practical judgement in my practice, rather than any knowledge or skills per se (Smith, 1999). Therefore, in Aristotle's terms, those contemplations, decisions and actions that any scientist enacts in his practice become habits of human character, both developed and manifested through this very conduct (Halverson, 2004). In the situations we find necessary to act upon, and the plans of action, which we set to life, we continuously develop and disclose our moral acumen (Dunne 1993, in Halverson, 2004, p. 3). Hence, one cannot base the assessment of a phronetic practitioner on an isolated action: "one swallow does not make a

summer" (Aristotle, 1999, p. 11). Phronesis is better understood as a more permanent and general state of being.

To Aristotle phronesis is not just any human virtue: he designates it as one of his cardinal virtues. To him it has a leading role in relation to the other virtues as it decides which other virtues to actualize in any specific situation, as well as how they should be proportioned (Aristotle, 1999, pp. 126-127). Schwartz and Sharpe (2006) emphasizes that it is crucial that the different virtues are not viewed isolated from each other and, in fact, that one cannot effectively act on any of them, if one tries to exercise it in isolation. The reason for this is that if one wants to cope with a specific problem, the first thing one has to determine is which virtues are relevant to this problem. Supposing we have been capable to accomplish this initial task, yet this does not tell us what specific action to carry out. It is also possible that the situation requires several virtues to be put to use, and if so, in what combination? Some of them might even be in conflict with each other. The different virtues do not come with a description for how and when one can or should exercise them. In this respect, to have phronesis is necessary to be able to judge which other virtues a specific situation calls for: like a master virtue essential for orchestrating the other virtues into an effective action (Aristotle, 1999, pp. 126-127, Schwartz and Sharpe, 2006).

As seen, phronesis flows from a vision of the good, and where the *phronimos* seem capable of contemplating well about what is good (Aristotle, 1999, p. 114). This ability to contemplate well does not exist without reason. Phronesis thus becomes some kind of reasonable and rightful thinking (Ibid, pp. 120-121). Furthermore, as closely related to the general human character, the ability to make phronetic judgements is something that one needs to foster through life experiences in its richest form. Any pursuit down some kind of narrow line of development, no matter

how well it might be in itself, even the one of natural scientific conduct, would not be sufficient, at least not over time. For any human to reach its fullest potential and to avoid stagnation, “experiences as a human being in every aspect of life” are needed (Nonaka and Toyama, 2007, p. 381). MacIntyre (1984, in Nonaka and Toyama, 2007, p. 381) even emphasizes that to foster insights relevant to master the living world that any human practice is we especially need to be open for “aesthetic experiences and a culture of philosophy, history, literature, and the arts”. The network of habits acquired through experiences from this expanded lifeworld becomes an embodied and moral compass of human character; ultimately, this is what determines the ability to act virtuously (Halverson, 2004). As Halverson (Ibid, p. 13), presents it: “we are our phronesis in a way we cannot separate ourselves from our knowledge”. In a manner, we are, or we become, what we do. We learn to be virtuous by our efforts to act virtuous, as a pianist learns how to play piano well by his efforts to play piano well (Aristotle, 1999, p. 24). In the way we perform our activities our human character is developed, though it is required that we recognize this, and that we take responsibility for our own general conduct and development as a human being (Aristotle, 1999, p. 50).

The vision of the good does not only become visible in regards to what end I ought to strive for realizing: The means that I use to achieve any given goal needs to uphold some internal goodness on its own as well. When performing a phronetic act I must attempt to realize the good through the very act itself. Every phronetic action applied thus surpasses some kind of strict instrumentalism, since I do not exercise it solely with the aim of achieving an exterior end, independently from the act itself. As shown by Polanyi, for an act in my practice to be at all phronetic, it is necessary that a human interest, engagement, intrinsic motivation and a personal drive is found in the act itself. In a manner, it is decisive that the acts, which I perform in my practice, themselves give meaning to me. In his famous *Hard Times* from 1854,

Dickens criticizes instrumentalism as he, as a contrast, invents a travelling circus. He presents the performances of the circus artists as displaying something like a confident mastery, or deftness, as if their performances constitute an "activity that seems done not for the sake of an external end but to contain its end within itself" (Smith, 1999, p. 338). Taylor (1992, in Smith, 1999) describes this as if they were connected to the *élan of nature*, meaning that their activity upholds some kind of *force, depth, vibrancy and joy* in which the "life of instrumental reason lacks" (p. 338).

Transferred to science, the scientist should not be willing to adopt any means to achieve whatever results he aims for. Firstly, he has to assure that the means applied are directed to some kind of rightful end, and secondly that they possess an inherent goodness. When the circus artists have accomplished this level of performance, they expressed what Dicken´s described as, "a remarkable gentleness and childishness about these people, readiness to help and pity one another, deserving often as much respect, always as much generous construction, as the everyday virtues of any class of people in the world" (Dickens, 1854, in Smith 1999, p. 338). Smith, who rendered Dicken´s description, further emphasized that the portrayal of these artists were "something very like practical judgement taken to its highest pitch of virtuosity and, in its strong connections with moral goodness and a way of life at peace with itself, something worthy of the name of practical wisdom**"** (Smith, 1999, p. 338).

This practical wisdom, or phronesis, becomes a kind of, more or less, stable action-oriented attitude, which enables us to master whatever human functions we do well. It also functions as a frame for further development, something that serves as an ideal to pursue in our self-transcendence. Furthermore, this attitude, or rightful thinking, is something attached to our general character as a human being, and it

entails a true, both reasonable and virtuous, concept about what is good for the individual that acts as well as for humans in general. This goodness is not found solely in the exterior end, but is also tried realized through the very actions we exercise themselves.

# VI. The ending: A completion

## The Process of Learning

I am back in my office, again trying to follow my trains of thought. With these steps within both a Polanyian and an Aristotelian landscape, I think I am closing in on this journey's final destination. What led to this reflection was that I, for a long time, had felt unease in relation to my professional practice, an uneasiness that I increasingly desired to explore. It was like a disharmony or an unbalance deep within, like my center of gravity in a matter was out of position. It was as if I found myself pursuing down a pathway, but rather than being a path that opened up on a new and more open terrain, it felt more as a narrowing pathway, a constraining element, perhaps something like approaching a dead end. In front of me, I saw a clearing, but the chosen path was seemingly not able to take me there. Hence, I had to take some steps back in order redirect the course, and now it feels as if the center of gravity is about to return to the right place: The plane is about to reach its destination. A feeling of harmony is becoming stronger, only the landing remains. Without being a pilot though, I assume that the landing is perhaps the most difficult part of the journey. Nonetheless, I have to get this plane on the ground: I have to finish this experience and make it a complete one.

According to Dewey (1934, p. 37), a complete experience is characterized by its own movement, from beginning to end, and in its separation from what comes before and what comes after. The different parts, episodes, actions and incidents keep their individuality, but also melt together in a union with its own rhythm and character, which again is what defines the movement (Ibid, p. 38). Most experiences, however, have a beginning and an ending that occurs without being noticed. One thing is being replaced by the next in a habitual laxity (Ibid p. 41), and these experiences are recognized in a manner covering up the demanding

questions. It is a symptom of our hurried and impatient society that our experiences do not seem to penetrate the surface. There is no possibility for completing these experiences, since something else immediately and instantly interrupts them. It is about doing most things within the shortest period of time, "the crowding together of as many impressions as possible is thought to be life" (Ibid, p. 46). Furthermore, another symptom of our society is that we treat any resistance met in our life as an obstruction to be beaten down rather as an invitation to reflection - as a possibility for learning (Ibid, p. 46).

Faced with a form of resistance, crisis, in life, whatever it might be, we have a choice. We can continue to recognize, or we can begin to perceive, i.e. awaken our consciousness or not (Ibid, p. 54). Lindseth (2015, pp. 43-44) describes this as the choice between the broad road and the narrow road. The broad is the easier un-reflected one, and the narrow is the hard one that leads to the possibility of learning. If we are unable to see these crises, or discrepancies, or if we are not open to see them, the broad road becomes the obvious one. To learn and develop, to self-transcend, we thus have to be open to accept these crises (Ibid, pp. 43-49): we have to be willing to, and have the impetus for, entering this, perhaps, hard and demanding narrow road. By embracing something difficult, something, which we feel a kind of resistance towards; our assumptions and preconceptions can be tested and made subject to possible nuancing and development (Ibid, p. 48). This process becomes important for avoiding being stuck in a “shallow, dogmatic or perhaps fanatical pre-understanding” (Ibid, p. 48). It is within these discrepancy-experiences that our critical thinking is awakened; hence, they become a prerequisite for learning, a fundamental necessity for being able to become wiser (Ibid, p. 47).

**First hand experiences**

To Dewey (1934, p. 46), having an experience implies that the human actions applied and its consequences unifies in perception. This is not the same as to act and reflect, or to do and undergo, in alteration: it is the relationship between them, when joined in perception, which gives meaning (Ibid, p. 46). As described, integrating the thoughts of Polanyi and Aristotle, the very starting point of this learning process is, however, our first hand experiences in the world. It is all the doings, in the place we are situated, what we stand in the middle of, at the moment we are there, which is the ultimate starting point for any process of learning. Through a comprehensive and long lasting socialization and cultivation in communities of practice, we, by a kind of imitation, learn how to follow the trails of established practice (Wackerhausen, 2009, Myers, 2002, p. 57).

Thus, our firsthand bodily experiences form the very basis for every knowledge expansion. When we come to know or to understand anything new, or when we develop, extend and refine one of our skills, this resembles an extension of our bodily knowledge of the world. This even applies, as seen through Polanyi, to the most explicit and objective parts of our knowledge. The tacit dimensions of knowledge are never absent: Any human´s inclusion of new external knowledge is always a self-development. The Cartesian legacy, with a divide-line between body and mind, between mind and matter, is demolished, as stated in Pirsig´s (2004, p. 225) classical *Zen & the art of motorcycle maintenance*: “Without objects there be no subjects – because the objects create the subject´s awareness of himself”. New clues that we rely on, or include, correspond exactly with this enrichment or “extension of our bodily existence” (Polanyi, 1961, p. 6). It is an expansion of our horizon of understanding: An expansion of our self into a new dwelling place (Ibid).

When we achieve higher levels of knowledge, it is primarily due to better abilities tacitly to grasp the essence of whatever we need to understand or practically perform. The knower becomes more capable in comprehending complex patterns of information when he does not see the pieces as isolated parts, but as large and meaningful patterns (Myers, 2002, pp. 51-56). The knower further becomes able to integrate information in new and creative ways and to see new connections within it, something, which again increases the ability to come to new solutions and new discoveries (Ibid, p. 56). According to Dewey, the aim of all intelligence is to grasp the full range of content and full range of connections in every experience (Dewey, 46) (Dewey, 1934, p. 46). It is, however, perhaps not possible to arrive to such maturity that all the relations involved are perceived (Ibid, p. 46). Yet, the act of grasping as many clues, or perspectives, as possible, serve like the ultimate goal to aim for.

**Reflection**

Our knowledge´s embodied existence becomes visible in our everyday routines, like automatized and well known practical doings that has become so natural, it might not attract our attention anymore (Wackerhausen, 2009). In this regard, Ryle (2000, pp. 41-42) emphasizes that it can be tempting to claim that this is nothing more than sheer habits. To him, however, there are two kinds of second nature: habits developed by drill, on the one hand, and intelligent capacities developed by training, on the other. Drill may manage well without intelligence; training, however, develops it. They have the execution of repetitions in common, but training surpasses pure drill because it involves criticism of the performer's own judgement, and, furthermore, this criticism also holds a kind of standard for comparison. The performer thus learns and develops while he is thinking and reflecting about what he is doing. Every act performed becomes a new lesson with a consistent aim to

perform better (Ibid, pp. 41-42). Ryle (p. 42) gives a pictorially exemplification of this act with a mountaineer walking over ice-covered rocks:

> He does not move his legs by blind habit – he thinks what he is doing – he makes tests and experiments – in short he walks with some degree of skill and judgement. If he makes a mistake he is inclined not to repeat it and if he finds a new method he will continue to use it and to improve it – he is concomitantly walking and teaching himself to walk. It is of the essence of merely habitual practices that one performance is a replica of its predecessors – it is of the essence of intelligent practices that one performance is modified by its predecessors – the agent is still learning.

To be able to see all the relevant clues in an act of knowing, it is not enough just to think within the box we usually do. Generally, when we think or reflect, or ask questions, we do so within a system of beliefs, like a framework for our conduct. What and how we think and reflect, or what questions and how we ask them, are however constrained by the system itself: it becomes a reproduction of the system, as it is, which has nothing more than a preserving and confirming effect (Wackerhausen, 2009). This, which Wackerhausen (Ibid) defines as the first order reflection, maybe makes us able to solve many of the problems we face in our practice, but it does not seem capable of finding out how and why we have a problem in the first place. It does not seem capable of getting us further. It is not enough to have the greatest insight in whatever subject matter we deal with, we also need a wider perspective: we need some distance. We need another, higher, floor on Jørgensen´s lookout-post[6] from where we can calibrate ourselves towards a

[6] I am however not to say that this "higher floor" was not included in Jørgensen's concept – I just thought it would be a useful metaphor.

greater whole, and it is first when we occupy such a perspective that we really have the potential to free ourselves from our own subjectivity by aiming for universal standards.

Another aspect to consider in this connection is that in this fast-changing, increasingly complex, global world it is not enough only to walk the established trails of everyday practice. Wackerhausen and Wackerhausen (1999) describe competent professional practitioners as humans among whom there is a broad consensus that they are able to meet the demands of the profession. As science is strongly anchored to society, e.g. in regards to the fulfillment of social valued goals, being a competent professional thus means to be able to follow these changes. The question asked by Wackerhausen (2009) is, how is it then possible to break the self-confirmatory reflective patterns of our established practice? How do we get to the new, and higher, floor on the lookout-post? How do we engage in reflective activities, not programmed to stabilize the already stabilized, but that have the potential to de-stabilize the stabilized? We have to attain knowledge and become acquainted with concepts, theories and ideas outside our tradition (Wackerhausen, 2009). As previously shown, we need experiences from every aspect of life, and, in particular, we need experiences of an aesthetic character (MacIntyre, 1984, in Nonaka and Toyama, 2007, Nonaka and Toyama, 2007).

These changes will force us to alter our conceptual background, our knowledge background, and thereby change both our patterns and possibilities of thinking and reflection. This kind of critical thinking is hence important to understand what we know and what we can, and it becomes vital for further learning and development. It opens the door, for each individual, to enhance the scope of recognition: it expands our potential horizon of understanding. This second order reflection is however not something that happens on its own, and it is not without risk and

without difficulties. Wackerhausen (2009) describes how when we begin to ask questions that exceed the boundaries of established practice the immune system of this life-world might strike back. Individuals who emphasize some kind of alien thoughts, questioning the very foundation of what is, may be exposed to the preserving forces exclusionary effects on the individual. As previously described, to go down such a narrow road thus has to be a choice made by each individual. If we doubt and criticize ourselves, we might become some kind of stranger to ourselves, and this may cause uncertainty in regards to our professional role and perhaps even a professional identity crisis (Wackerhausen, 2009). The stronger the link between the self and the professional identity is, the stronger the feelings of uncertainty and crisis can become (Beijard et al., 2003). Understandingly then, our professional role and our professional identity are not something stable or fixed; on the contrary, they are dynamic and part of a potential life-long learning-process of interpretation and re-interpretation of experiences (Kerby, 1991, in Beijard et al.,2000, Beijard et al., 2003).

Wackerhausen (2009) describes this process of change as doing maintenance and replacements on a boat at sea. If we change too much at a time, we are in trouble: the boat will sink. It is no need for the pace of the process to be too hasty. It is better to consider it as an everlasting process of fixing one thing at the time, while still being able to uphold normal activity. So even though we are learning, taking on new perspectives and expanding our horizon, we have to hold on to what we are. We have to steer away from what *nineteen-hundred*[7] did in *The dance on the golden parquet* when he was led to believe that "the lives and revelations of others were more right and more real than his own" (Jørgensen, 2008, p. 41). He did not settle with the attempt to include, integrate, other humans' perspectives into the vision he

[7] Based on the text *Novecento* by Alessandro Baricco, 1994.

already had. On the contrary, he desired for seeing the world as the other did – to adopt their view. It was however a self-defeating and fatal realization, to recognize that his attempt to leave the waters he was most familiar with was absurd, because it was these waters, and his desire for understanding the greater world *out there* that, in fact, had made him all that he was (Ibid pp. 35-43).

As emphasized, these reflective abilities are synonymous with the ability to think. This is one of the most essential attributes of humans, emphasized in the work of Dewey, Polanyi and Aristotle. To Dewey (1934, p. 47) the actor that does not think is not "aware of what he is doing and where his work is going". To achieve a completed experience, one must see every part in relation to a whole; and the ability to capture these relations is, according to Dewey (Ibid, p. 47), one of the most demanding ways of thinking. Furthermore, to him (p. 58) the whole is also present in each phase, not like a sheer end, but more like a continuously fulfilling function. Hence, where the artist "is in process of completing at every stage of his work" and where "he must at each point retain and sum up what has gone before as a whole and with reference to a whole to come". The actor that succeeds in this will also succeed in gaining consistency in his subsequent actions; and, in a manner, all the different parts unify (Ibid, p. 58). Consequently, each experience upholds some kind of form, or some kind of dynamic organization (Ibid, p. 57). Dewey here characterizes this (kind of) experience as dynamic, since it takes time to complete, and because there is a growth, and the material is being ingested and digested and related to previous experiences (Ibid, p. 57). It hence takes time to fulfil, "To learn well is to learn slowly" (Næss and Haukeland, 1999, p. 155).

**Our contemporary world**

A good learning process is thus not a straightforward procedure. Besides the required willingness, which must be present like a driving force for any self-

transcendence, we also have a challenge with respect to how we, in our contemporary world, have structured our society in a manner making learning difficult to nurture. Learning requires some kind of freedom, time and autonomy so that we can act according to what the situations we face in our practice truly call for; and this is something we are not necessarily provided. The mistaken idea, or notion, that it is all about doing as much as possible in the shortest possible time, limits humans' leeway, thereby impeding the possibility to go to the frontline and to go below the surface of anything at all. Furthermore, the human acts of comprehending, making judgements and decisions, are something the contemporary world, dominated by technology, rules and regulations, appears to present us with less unconditioned opportunities for exercising (Smith, 1999). Any deliberation about a choice of action within our practice is, in a manner, made for us, and not by us, and these deliberations hence stand the risk of becoming superfluous. In all areas of human enterprise, it has become so important to follow standardized procedures that it has deprived us of the possibility to exercise, and further develop, our practical judgmental abilities. Of course, we need the systems, but above all, we need the abilities of the humans operating the systems.

In this mechanical world, the professional practitioner is supposed to base his doings on universal knowledge and in a systematic and structured manner apply this on particular occasions. I believe this points back to the idea of the existence of some kind of perfect knowledge: the existence of absolute and universal explicit, definite and unambiguous answers that each individual, by principle at least, can and should apply. A negative implication of this notion is that this externalization of knowledge has contributed in disconnecting knowledge from the individual that holds it to the extent that we have stopped believing in our own beliefs – that without this universal knowledge we are only groping in blind. Another worrying aspect of our current situation is that this idea, that the absolute correct answer is possible to

find, has created a fear of not having the answer, a fear of making mistakes. In many circumstances, it has even developed into a policy of no acceptance for making mistakes. Consequently, one triggering factor for the standardization of any human enterprise is the desire to try to simplify our existence by steering clear of any bumps on the road, any difficulties we may face. A human eagerness to categorize, to designate things as black or white, and to have absolute certainty in relation to whatever subject matter we are dealing with.

Our human world is however, as seen, not that simple. It upholds a much higher diversity and complexity in which the adequate response to any problem seldom reduces to an unambiguous answer. This does not imply that we ought not to strive for the best way to respond, it just means that the best action is not necessarily tantamount to an absolute answer, and that we often reach it by uniting different perspectives upon the problem: even by uniting apparent contradictions. Often our abilities to see and synthesize what appears as contradictions are what make us capable of coming to rightful conclusions (Iizuka, 2003, in Nonaka and Toyama, 2007). Martin L. King (1964, p. 7) said that the truth is never found in a thesis, neither in an antithesis, but in a synthesis. Furthermore, any confusion or contradiction found in the way we organize our social structure, are thought to be overcome by the introduction and bolstering of these technological, mechanical and bureaucratic systems, standards and routines. The confusions and seeming contradictions are, however, not as much obstacles to overcome, as they are, as we have seen, enablers of further development.

It is perhaps not that strange then that the natural scientific conduct itself, where these thoughts originated, is governed, to such an extent, by these very thoughts of perfection. The perfect knowledge is for the scientist, with the previously mentioned scientific “systematic protocol and technique” (Burrell and Morgan, 1979, in Cox and

Hassard, 2005, p. 114), to find. In a manner, natural science has become reduced to no more than, this monstrous conception of The Scientific Method. Science, hence, reduces to some kind of technology-based production, based on rigid standardizations, procedures, rules, and so on, and the scientist´s conduct and the outcome of this production brought together with so much scientific glue that there is no room left for mistakes to occur (Smith, 1999). We may wonder if it has gone so far that, it has resulted in an attitude that as long as one applies the scientific method correctly, everything is as it should be. As seen through my story and the discussions above, though, this denies the scientist the exercise of his own judgmental abilities, as well as his own knowledge.

With this fear of making mistakes, it has gone so far that we even have removed the human from the picture. We have at least narrowed down the understanding of the human and the human's contribution in whatever function he or she attempts to fulfil. We have reduced him or her to no more than a calculative machine with the aim of exactly calculating the unambiguous answers, steering away from any difficulties whatsoever. This reveals a major distrust in humans' knowledge, and a lack of understanding, how further to develop it. If we however were to continue down this road, if we were to accept such a reduced and simplified concept as an ideal in the decision making process within any human enterprise, it would be interesting to see what the consequences, ultimately, would look like. As a matter of fact, in plain situations, all relevant data and rules being explicit and unambiguously given, computers or statistical models, according to Hogarth (2001, pp. 148-149), perform better than humans. He further explains this as due to better consistency in the computers, always coming to the same conclusion, based on the same explicit information, something that humans do not.

On the other hand, when the complexity of the situation rises, and the amount of clues to be accounted for is increased, humans seem capable of capturing information which computers or statistical models are not able to recognize (Ibid, pp. 148-149). Furthermore, our aim, I believe, is not to be stuck in some kind of closed problem-solving circle: we want to bring the world forward. In line with this, the human has the ability to make new connections and seeing new creative patterns and making new solutions become visible (Myers, 2002, p. 56), in ways that I believe surpass any machine-like function. Another problem with retaining this mechanical belief is that it develops into a self-reinforcing process where more standardization, more rules and, in overall, less autonomy within our professional conduct leads to decreased learning. This again leads to reduced knowledge and reduced skills among the practitioners, which again leads to more (methodical) rigidity, more standards, and procedures being required and so forth (Schwartz and Sharpe, 2006).

The fear of making mistakes has further manifested itself in a control-system, a reporting bureaucracy, beyond reasonableness. Clearly, control-systems, which also hold some kind of standards for how to report, are needed, in a various amount, in most human practices. In my opinion, however, we have let it go too far. One problem is that these standards for control to a high extent take on the same technological-production based expression, which I now have problematized (Raffnsøe-Møller, 2011). Everything done is being controlled and reported based on quantitative measures, which in my opinion are nowhere near being a true reflection of what is actually done. Another problem is that these very control-systems function simultaneously as external reward- and incentive-systems, which motivates for the same kind of performances (Ibid). Hence, the mistaken idea that we have to produce as much as possible, quantitatively as much, that is, so that we can then tick it of on our checklist, is further strengthened. Again, if we turn to the

previous description of our hurried and impatient society: it is about doing as much as possible in the shortest amount of time. Of course, it is possible that we are in fact useful, but at the same time, our conduct stands the risk of being no more than some kind of useful idiocy. Perhaps it is about time to begin trusting the human being again.

**Technological logic**

One may understand the modern knowledge and science view, or the mechanical belief it represents and supports, as some kind of techno-fetishism, rationalism or technological logic, which in a manner corresponds to some sort of a worldview. Wackerhausen (1992) describes it as some kind of colonialization of, and norm-setting function of our human life world. If we do not think about it, we may not see it, but it is there, controlling so many parts of our lives, having severe implications regarding how we understand knowledge, skills and the process of learning as well as any human conduct in general. Furthermore, on this view, in the desire for universal objective absolute and explicit knowledge, the perfect truth, the understanding of knowledge in a manner has been reduced to a purely cognitive access to the world (Lindseth, 2015, pp. 50-51). Scientifically-based knowledge has gained some kind of monopole status (Wackerhausen, 1992), the understanding of human intelligence being reduced to primarily being about the intellectual exercise of theorizing where the aim is detecting and upholding true propositions or facts (Ryle, 2000, p. 27).

With these thoughts there also arose a notion that “the capacity to attain knowledge of truths was the defining property of a mind” (Ibid, p. 27), and consequently that every other human power where only to be categorized as mental or intelligent, if a connection to the intellectual grasp of true propositions were identified (p. 27). Ryle (p. 27), however, claims that there are many things that

reveal the qualities of a mind that do not necessarily reflect intellectual operations. He further states that intelligent practice is not some kind of stepchild of theory. On the contrary, the act of theorizing should be considered as something, which one can carry out both intelligently and, perhaps, stupidly. To him (p. 27), this is no more than an "intellectualist doctrine which tries to define intelligence in terms of the apprehension of truths, instead of the apprehension of truth in terms of intelligence".

The identification of the failures of the intellectualist doctrine, and its consequence, the technological logic of practice, is something, which can be followed all the way back to Plato, who in the dialogue *Theaetetus* presented the conception, although not as his own, of knowledge as true justified belief (Lindseth, 2015, pp. 49-50). Even Aristotle placed scientific knowledge (episteme) on a kind of pedestal, and in a way left the human in its full extension out of the picture. He, as the honorable defender of practice and practically oriented knowledge (phronesis), has also contributed to the conception of the inferiority of practical knowledge to episteme or scientific understanding, since he considered the latter as the most esteemed kind of knowledge, because it dealt with the most valuable objects and the most complete forms of knowledge (Aristotle, 1999, p. 117). This still prevailing dualism thus has deep roots.

The desire to be able to argue based on clear, rigid and valid statements is associated with a longing to be able to step forward with some kind of authority, or to be some kind of expert capable of executing well-founded disseminations. In the modern world, the scientist became regarded as an *expert par excellence* and science as the *expert system par excellence* (Evetts et al., 2006, p. 106). Science, hence, became a powerful and prestigious authority of great significance (Fuchs, 1992, and Maedows, 1992, in Resnik, 1998, pp. 31-34), somehow making the

scientist the ultimate manifestation of the expert role: the ultimate expression of professionalism. The increased standardization, or professionalization, of science can therefore, to some extent, be understood as a system of "social closure: a group´s attempt to delineate and close from the outside world for more efficiently [to] achieve and preserve privileges for the members of the group" (Laursen, 2004, p. 23).

This system, then, is something that has arisen because it has been advantageous for the scientists' themselves, in their pursuit of professional goals and the acquisition of intellectual authority, as well as in the protection of scientific autonomy and career opportunities (Gieryn, 1983). The question we might ask ourselves now is if we in the fear of losing this status, this facade, this stronghold and this hegemony, have blocked out, distanced ourselves, or somehow, perhaps unconsciously, concealed any uncertainties that might have jeopardized this advantageous social position. Ultimately this then, comes down to some kind of exercise of power (Fossestøl, 2013, p. 61). To quote MacIntyre (2007, p. 181): one function of human virtue in practice is exactly to "resist the corrupting power of institutions". This emphasizes, to me at least, the urgent need for contemporary natural science to embrace humanity in its fullest and to let the ethical dimensions of our humanity inside.

We can also view this issue from the other side, concerning how society has contributed to, at least to sustain, the problem. The general conception is that clear and rigid statements, presenting final, objective and neutral answers, are how professionalism is expressed (Fossestøl, 2013, p. 60). Consequently, from the surrounding society, there are expectations that this, ultimate, expert group is capable of emerging with, and expressing, this kind of professionalism (Ibid, p. 60). In this picture of professionalism, the wider human side of science clearly did not fit

in very well. The notion thus occurred that the display of human engagement, interests and values resulted in a loss of professionalism. Hence, the scientist became insecure in how to articulate the connection between his moral and his professional commitments, and the expectations about professionalism, coming from the surrounding world (Ibid, p. 60). In my opinion, we can now recognize and take another standpoint: that any attempt to get rid of the acting human being in its completeness is comparable to throwing the baby out with the bathwater.[8]

Naturally, this view, as mentioned, affects how we think about the process of learning. Learning from experience, and the reflection upon this experience, what Lindseth (2015, p. 49) describes as the dialectical method of taking into consideration and critically think through our life, choices and actions, is often neglected. On the contrary, learning has almost become synonymous with the transfer of theoretical knowledge: scholastic learning. This conception of learning originally gained dominance, and still has some kind of precedence, because those who are arguing for learning from experience, and for the importance of the tacit dimensions of any process of knowing, naturally enough, are not capable of presenting the same level of clarity and validity in their statements, as those who represent the scholastic view (Wackerhausen, 1992). This "academic haughtiness" thus has deep roots (Ibid, p. 87).

Furthermore, I believe it exist some kind of academic naivety concerning the impact educational institutions have on the process of learning. The educational institutions, and those teaching within them, cannot give or transmit theoretical knowledge to anybody. Only the learner can learn. The essential elements for

[8] This idiom derives from a German proverb, *das Kind mit dem Bade ausschütten.* The earliest record of this phrase is in 1512, in *Narrenbeschwörung* by Thomas Murner.

learning to happen are then again the melting of horizons, the establishment of empathic relations and the awakening of the learners' critical thinking. This is, however, not to say that we should altogether abandon scholastic teaching. However, we need to reorient ourselves about how we can organize and facilitate for the best possible learning to take place. Additionally, we need to begin to acknowledge that the formal and higher educational systems are not the end-product, but rather the very starting point, of what to come: the enabler of what to come, where the primary aim is to facilitate for developing the learner´s curiosity, engagement, motivations and willingness for further learning in a life-perspective.

In my opinion, however, these thoughts do not provide anything new to the discussion. It is more like a repetition of things heard before. Maybe the top-down transfer, some kind of monologue lecture, of theoretical knowledge to a large and silent number of students, where those necessary empathic relationships are impossible to form, is not the preferred teaching method in higher education. Perhaps it is just some myth that it is. Yet, the myth seems to die hard, and it seems to be a gap between what we may agree upon theoretically, and to what manifests in practice.

**What to aim for**

The extent to which this intellectualist doctrine influences other aspects of our society is hence of substantial magnitude. I believe it has crawled so deep beneath our skin, and unconsciously it haunts us like a nightmare. In a manner we have become so deeply occupied with finding, and preserving, the absolute truth, and avoiding to disclose anything else, that instead of listening to those who speak otherwise we have shut the door and painted us into the corner. In our satisfaction with what is, we constitute our lives through a kind of mirror, in which we are most concerned with seeing ourselves (King, 1964, p. 11). With these feelings of our own

excellence, we, as it seems, have developed almost a fear of meeting others that feel the same way about themselves. To avoid that this happens, we have thus closed down the water supplies to where we are swimming to such an extent that what is left is nothing more than a motionless pond. Perhaps we are big fishes – yet big fishes in a small pond.

Some of my own desire for mastering the life-world of science is, then, ultimately nothing more than a desire to become this intellectual and professional expert who with academic authority can base my arguments on scientific knowledge: In a way, to become a priest in the church of intellectuality (Pirsig, 2004)[9]. Yet, although we may be capable of reaching some kind of knowledge or insight in the subject matters we are working with, the question is if we, due to some kind of narrow-minded stagnation, are not losing the greater picture – the greater entirety. Furthermore, that this restriction also restrains our own scope of opportunities. I believe we cannot allow ourselves to settle down in complacency with these feelings of satisfaction; we cannot be content with swimming in this small pond, although it feels so pleasant. We need to swim in greater waters: We need to open ourselves towards the great oceans. Other big fishes are not a treat to us. On the contrary, we are part of the same world, and we are practically different parts of the same thing: If they grow, I grow. What is remarkable is that although most of us, I believe, would agree on this, it still seems so difficult to break free from this intellectualist doctrine. It seems as though we, when locked up in a tradition, such as this, and in this way, in a manner stand the risk of keeping watch over our own chains (Gadamer 2003, p. 14).

[9] Pirsig wrote about the church of reason (not intellectuality) and he did not mention any priests either.

Furthermore, I have come to realize that my initial high confidence in the scientific machinery corresponds to something like a high confidence in the scientific method. I have been so occupied with following this system, mastering this life-world and all the elements within, the standardized methods, the procedures and so on, that I forgot to ask: for what reason? However, my practice does not only consist in how well I practice my skills, but to what end, I do so. In this (the scientific) world, where we have become so eager in doing, we have forgotten to attend to where we aim our efforts. This takes me back to the previous description of the scientific practice as reduced to some kind of core technology of what scientists´ do, where Smith (1999) referred to the practitioner, as the scientist, as a kind of primitive machine upholding no more than predefined competencies. Furthermore, even though the methods that I have applied in my scientific practice, in themselves, might be within an adequate practice, it is not enough to just enter a practice, no matter how well it may seem to be established, if I do not bring my own professional judgement along with me.

Smith (Ibid) even takes his criticism, of what he describes as a naïve admiration of this logical technicism, further by claiming that it is beginning to parody itself. In a way it even surpasses the competencies or skills the practitioners hold: "the elevation of means above ends"..."the means appear to have kicked free of ends altogether and whirl, beatified, in a technological utopia" (Ibid, p. 329). This technicism also resembles Wittgenstein´s apocalyptical beliefs about humanity, as he meant it would come because we replaced ends with machinery, and that humans had put their faith solely in the scientific progress[10] (Monk, 1990, p. 427). Furthermore, the means are not only being kicked free from the ends: the natural

[10] Wittgenstein's thoughts in this relation was based on the frightening proof of technological power through warfare.

science in its search for objective truth, freed from the context and the individuals who hold this truth, freed from society, have gained some kind of power of definition about what problems to be pursued. In this vacuum however, science stands the risk of being no more than a *king without a kingdom*[11] (Aarnes, 1996, in Asdal 2005, pp. 254-255).

Smith (1999) also exemplifies the problem of means solely becoming ends in themselves through Dicken´s *Bleak house*. A lawyer´s aim, or external end, in relation to a case, is to win it for a client. To this end, the lawyer needs to have knowledge about the law, and he needs to be convincing, attentive and reasonable. When the lawyer *is absorbed in the ethos of practice*, these elements become internal to him, and for this reason, those observing the practice may not recognize them being there simply to help him in winning the case. However, these elements may also become ends in themselves, and then the connection to the reason why they were there essentially, becomes lost. If the link between the lawyer´s practice and the "wider ethical values and ideals is severed, the lawyer becomes not a model of practice but a caricature" – his "professionalism becomes a substitute for his ethical being in the world rather than an expression of it" (Ibid, p. 336).

This professional that I desired to become is thus not enough, when not linked to the ethical and moral life and responsibility (Ibid). I am thus left with a feeling that I, in my in my desire to become this priest in the church of intellectuality, this professional, lost something on the way. I neglected these, deeper, attributes of my human character in the developing process, and not just that, but also, in a manner,

[11] Here I borrow, and make a little twist on, Aarnes' metaphor where he originally stated that it was positivism that had become a king without a kingdom.

forgot that they were there in the first place. Hence, it felt like I lost something of myself: I was so occupied with becoming something that I forgot that I already was.

The noble human on the contrary is the human that is capable of working deliberately *without losing himself* (Letwin, 1982, in Smith, 1999, p. 336). If we take up on the concept of phronesis again, we have seen that the guiding virtue of these noble humans is related to the ethics of belief, that it is some kind of discernment required to perceive the world with accuracy (Smith, 1999). Any human development within this system of thinking hence becomes connected to the idea of truth, because the learning human "attends to the world as it is and not through the distorting mists of self-deception or fantasy" (Smith, 1999, p. 334). It is however a "long and difficult struggle – neither the dramatic leap nor the inevitability of false consciousness – to rid ourselves of characteristic forms of (moral) blindness" (Ibid, p. 334). Any process of knowing or developing hence holds not only an epistemological but also an ethical appeal (Wackerhausen, 1992). I believe it is about time to free ourselves from the intellectualist doctrine, to free ourselves from this ignorance, this blindness, or dead-end, of both knowledge and moral character: To step out of this morass of nihilism (King, 1964, p. 9). Again, and now even more powerfully expressed: my struggles for development become a struggle for the fulfilment of my personal responsibilities to universal standards.

It is about having the power to realize concepts for the common good, and being able to take in consideration, and balance, the viewpoints of others. Like Aristotle's golden mean where we attempt to avoid extremes and to solve contradiction by the appliance of moderation. It is a harmonizing and synthesizing act requiring us to think *both and*, not *either or*. This expands our struggles where we place everything we know and everything we do in a wider context of human meaning. We become humans with a humble attitude towards the world, which enables us to

acknowledge and respect other views. Josefson[12] and Nussbaum (1997, pp. 50-84) describes this as something like the development of good citizenship, a worldly citizenship. To be able to come to a new understanding of whatever subject matters or human beings we attend to, we have to acknowledge it or them for what they are. For this, we need empathic, open-minded and compassionate approaches, we have to try to assume the other perspective, and strive for our horizons to melt together. We have to meet some kind of resistance with open arms because that is how we secure that the world does not stagnate, but can continue to be developed. By this, we become capable to see beyond, and to overcome, one-sidedness, we build bridges and tear down barriers and we integrate opposites and contradictions. By this development, we are now becoming stronger humans: Humans that are carrying strong contradictions within their character (King, 1964, p. 7).

Yet again, this requires willingness to self-transcend. We have to be willing to go to the frontline, even in an expanded version. In a manner, the life-world which we recognize and which we desire to master expands. It increases our range of opportunities, our framework for reflection and learning, and accordingly increases our potential horizon of understanding. We are provided with more shoulders of giants upon which to stand.[13] Our life of meaning and engagement can become even more enriching. As already understood though, this does not imply that we ought to engage ourselves in, and attempt to master, all different things and in all different directions. Though it means that we have to do what we do the best we can, and therein lays the fact that we need to consider the things we do as part of a greater

[12] Josefson, I. The lecture *Practical Knowledge and Education,* held 28.04.2016 in connection with the PhD course *The Theory of Practical Knowledge* at Nord University, Center for Practical Knowledge.
[13] The metaphor is based on the expression "standing on the shoulders of giants", which has been traced to the 12th century and attributed to Bernard of Chartres. However best known today by Isaac Newton's use of it in 1676.

entirety. Whatever little thing we now do, we are doing it in a great manner: An attitude corresponding to the very art of life (Næss and Haukeland, 1999, p. 163).

This ethical thinking, or knowledge view, is, to me, the ultimate integration, a uniting force, of all partial systems affecting my human behavior. It can be understood as given "with the shape of a life – and further what it means for the individual to be embodied within the natural world" (Smith, 1999, p. 332). It opens the door to incorporate the human in its fullest, it embraces the cultivation and formation of the whole human being, it opens the world's multiplicity and do not close again as the modern science and knowledge doctrine did with its expectations of simplicity, reduction and precision. This ethical view also accepts that the only and ultimate starting point for what to come is ourselves as and where we are at this very moment. Consequently, it also accepts our own inadequacy and our fragility as something corresponding to the most beautiful of human life and something modern science has tried to deprive us of with its longing for certainty and control. It gives an acceptance of my knowledge of the world as some kind of uncertain, complex and dynamic process of knowing, because it exactly mirrors the complexity and dynamism, and with its even unknown future manifestations, of the world itself. The results of my intellectual, methodical scientific endeavor, if correctly aimed, hence have the potential to become a fusing force between my knowledge, my beliefs and my assumptions, of this reality and reality itself. A force that potentially can transcend both (Pirsig, 2004, p. 274).

In the last chapter of the previously mentioned classical book *Zen & the art of motorcycle maintenance* (Ibid, p. 392), the narrator's son asks him if he could have a motorcycle when he grows up. The narrator answers *yes, if you take care of it*. The son then asks if it is hard and the narrator's answer to this is "Not if you have the right attitudes. It's having the right attitudes that's hard".

## This Reflective Journey: What it is

When I am now closing in on the landing strip, a question appears in my mind. For what purpose has this expanded and perhaps somewhat unorthodox comprehensive introduction in my PhD, these extra miles, been good? I started out with a description of my natural scientific practice, told through two narratives. In the first one, I took for me the evident – a recapitulation of my published research. Through this review, I found some kind of pattern, or common features, in my practice, wherein what and how I had done things became clearer to me. However, new questions arose, as I understood that there were some underlying forces that, in a manner, controlled both what I was doing and how I thought about what I was doing. Furthermore, as I did not feel completely familiar with what I found, the rest of the journey developed into an attempt to nuance, expand and develop the picture of what I believe natural science at its best can look like. If we follow Lindseth`s (2015, p. 48) thoughts this essay hence constitutes a composition of the life-road (Greek: hodos) in which I have walked, and the meta-road (Greek: methodos) in which this life-road of mine are taken under consideration.

Nevertheless, as a whole, this essay thus is a study of my scientific conduct in a broad sense. The purpose with such an approach is not to be conservatory or unitary, since the essence of practice is of interest due to its variations and not due to its mean (Chia 2004, and Whittington, 2004 in Nonaka and Toyama, 2007). To get under the surface of any human practice, we need extensive descriptions: the very *thickest of thick descriptions* (Smith, 1999, p. 337). This can disclose the whole inside of practice, which is not solely the existing practice, all the visible things, it is the entire spectrum of consideration and reasoning done by the practitioners where they "make judgements and decisions about situations they confront and actions they must take" (Shulman, 2007, p. 560). According to Heidegger (1993, in Shulman, 2007, p. 562), we have the *actual* (practice) but there are also *the wealth of the*

*possible* and the *stringency of the necessary*: “the actuality of the actual is contained in being, but also the possibility of the possible and the necessity of the necessary”.

If we succeed in opening up, and letting the real content of the scientific conduct out into the open, we also become able to have and open discourse about science in all its diversity (Dash, 2009). In such a perspective, the discourse is much better off with “view[s] from everywhere - embracing the diversity of world” (Grobstein, 2005, p. 12). Hence it may be possible to reduce the recognition of science as an isolated activity that only some get to partake in, and on the contrary make it the product and property of all humans by giving insight for outsiders of the “paradise that science has created” (Broad and Glantz, 2003, in Grobstein, 2005, p. 2). To me, it is a timely question now to ask if not today’s form of discourse in and about science simply comes up short in giving a truthful description of how really qualitative scientific work looks like. The way scientific knowledge is disseminated today – how the scientific story is told - is thus in urgent need of revision. I believe the form and structure of the standardized and rigid scientific reports, as well as the publishing process in general, both are continuing and reinforcing the fundamental assumptions of modern science, which I now have problematized throughout this essay. As these scientific publications, and this publication system, have a special position when it comes to defining the standards, the rules of conduct, for the scientific enterprise, such a discussion is vital.

Nevertheless, when we cast a look inside any human practice, we do not only enter the world of the current practitioners: We also enter the world of the preceding practitioners (MacIntyre, 2007, p. 273). We are entering into a tradition. It is hence a paradox, for me at least, that it is this tradition that I somehow confront, within which I also have learned, and will continue to learn. It is clear that every practice has its history and everyone who wants to be learning members of this practice,

have to expose them to every feature and standard of what is considered good within it (Ibid, pp. 190-194). However, what is defined as good is something that regularly has to be questioned (Ibid, p. 273). MacIntyre (pp. 221-222; 260) thus emphasizes that even though we follow a tradition, this does not entail leaving behind reason, and that to have some kind of stability does not have to exclude any conflicts and desires for improvement. In fact, every discourse happens within a frame of context, which the tradition itself has contributed to determine. Even the sustaining and developing forces of this tradition we find in the discussion of what to come: It is about seizing the opportunities the past has made accessible (Ibid 221-222; 260). For my part, I am grateful for being part of this fabulous tradition that science is – I just believe we can do it even better. I believe we can accept and acknowledge more things into the box we call scientific knowledge, as well as into the process of developing this knowledge: To what we can agree upon constitutes science.

In the preface of *The Logic of Scientific Discovery*, Popper explains something he terms the problem of cosmology, "the problem of understanding the world – including ourselves, and our knowledge, as part of the world". To him this is something all thinking humans are pursuing and something that exists within every scientific endeavor. Whether concerning specific research questions or the more abstract philosophical questions, the quality of it comes down, to what extent it has contributed to formulate and solve this problem (Popper, 2002, Preface). In this regard, a question that remains unanswered is, perhaps, whether this reflective journey has any kind of scientific interest. The thickest of the thickest descriptions of any human practice is not possible to verify in the same ways as perhaps some kind of pure scientific representation. It has however a potential to carry a different kind of validity. Bruner (1986, in Halverson, 2004, pp. 26-27) argues that the quality of such representations comes down to two concepts. *Fidelity,* which corresponds with

some kind of accuracy: that the presentation renders what it is supposed to be representing – that both the description of my practice and my own critical thinking and/or interpretation of the literature I am thinking alongside with, is as correct as possible. *Verisimilitude* with an audience, which means how well the readers can recognize themselves in the representation; in a way it is a question concerning its plausibility. In my opinion, this also comes down to whether this journey has any universal significance, first, in relation to science in particular, but perhaps also beyond science and into other human contexts as well. Whether the readers can see themselves in this representation and whether they can find something reaching some kind of universality is a primary goal for me, as the author, to facilitate, to attempt for the borders between our horizons of understanding to be melting; yet, this also requires receptiveness, on the part of the readers.

This reflective journey is still just a reflection, which perhaps, if initiated at another time and another place, could have taken other courses of direction: as we have come to understand we will always see what we see from where we see it, this is inevitable. For me this journey, that I have invited you to follow alongside, has been a personal and self-developing process of significant magnitude. This essay hence becomes, both in content and form, some kind of ultimate manifestation, a merging force, of who I am, or who I have become, as a professional, and, even as we have come to understand, who I am as a human being. I have let you in beneath the surface of my practical doings, and I have let you take part in some of my deepest thoughts concerning these doings. I have disclosed my own unique position in the world of science. Such unique positions - every human have one - constituted by the personal and contextual elements, make us what we are. They are also, as we have come to understand, the ultimate, and only, starting points of what to come. They are what enable each one of us to see something in a different way than other

humans do. They constitute the ultimate and only starting points from where external ideals or values can be attempted realized.

I believe it is vital to acknowledge these unique perspectives that each person has developed, as an unconditionally positive force, since this makes us really stand a chance in seeing beyond the conservative turnaround, the boundaries, of established practice. The personal aspects of each knowledge-expanding process, also reveal, as described, that we sometimes, as I, with my entrance into the police context, feel as if standing on shaking ground. These processes of uncertainty, where we to some extent do not have an established practice, a methodical and conceptual consensus, to support our actions is, however, inevitable, because, if to really have a substantial scientific development we have to go outside the frames of what is already there.

This connection between the personal development and the pushing of boundaries related to any established practice also emphasizes, to me at least, another important reminder. When every knowledge expansion, every new understanding, primarily, is a personal, or interpersonal, human project, it is these humans that make the established practice what it is. By this, we also understand that no professional practice, in some kind of passive manner, can ever develop by itself. For a professional practice to develop it is thus dependent upon the humans themselves to develop. Hence, this essay, this whole personal reflective journey, in a broad sense, represents an attempt to develop the professional practice of sport and exercise science.

However, perhaps I have not raised enough critical questions upon the course that I have now traversed or the expanded position in which I now find myself. Yet, I do believe that this constitutes another journey. The aim of this essay was

understandably not to provide any final verifiable answers. However, hopefully it can contribute to a reflection on your part, and hopefully it can contribute as a voice of some importance in something like an everlasting and dynamic ontological and epistemological discourse: Because that is what it is and that is what it should be – everlasting and dynamic – and where this is my little contribution, nothing more, nothing less. And, yes, I do know, now, what the professor meant. Do you?

We have reached some completion, and have finished the experience: the plane is on the ground. Or, as we have come to understand it now it is not that easy, is it. It feels more like the plane just touches the surface briefly before again accelerating towards an immediate new takeoff. It emphasizes beautifully, and reminds me, that everything we understand is still just a part of a greater dynamic process of knowing and that in this process there is no such thing as a finish line, no such thing as an end. The circulatory motion continues; that is of course if you are willing to follow along with it. For me, well, I am airborne again.

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Studies 1-6 in full text

**Study 1 in full text**

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# AEROBIC CAPACITY AND ANTHROPOMETRIC CHARACTERISTICS OF ELITE-RECRUIT FEMALE SOCCER PLAYERS

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**Abstract** Knowledge concerning the young talented female soccer player is lacking. Therefore, the aims of the present study were to identify and establish aerobic capacity and anthropometric characteristics in 32 Norwegian elite-recruit female soccer players and to examine possible aerobic capacity and anthropometric differences between playing positions. Measurements consisted of two standard anthropometric variables as well as the anaerobic threshold (AT) and the maximal oxygen consumption ($VO_2$max). The results show that the keepers' running velocity at AT (7.9 ± 1.1 km/h) was significantly ($p \leq 0.05$) lower than that of the midfielders (10.0 ± 0.6 km/h) or the attackers (9.3 ± 1.1 km/h). No $VO_2$max measurement differences were observed between playing positions, and the anthropometric differences were limited to keepers having a higher body mass index (BMI, 24.2 ± 0.5 $kg \cdot m^{-2}$) and a lower reciprocal ponderal index (RPI, 41.4 ± 0.6 $cm \cdot kg^{-0.33}$) than either attackers (20.5 ± 2.2 $kg \cdot m^{-2}$; 44.1 ± 1.6 $cm \cdot kg^{-0.33}$) or midfielders (20.7 ± 1.9 $kg \cdot m^{-2}$; 43.6 ± 1.3 $cm \cdot kg^{-0.33}$) ($p \leq 0.05$). Present results indicated similar aerobic capacity in the subject group when compared to previously published findings. However, previous data showed that different playing positions had different physiological demands, but these differences were not reflected in the capacity measures across playing positions presented here. Hence, present findings suggest that the coaching staff should individualize physiological training programs to improve the players' abilities to cope with the specific demands of the various playing positions on an elite female soccer team.

***Key words:*** Talent identification, talent development, maximal oxygen consumption, anaerobic threshold, body mass index, reciprocal ponderal index

## INTRODUCTION

Soccer has been mentioned as the most popular sport in the world [25], and research indicates that the demands on elite soccer players have increased in recent years [2]. Thus, soccer player profiles and the developmental process towards becoming an elite performer have both become subjects of decisive interest. Therefore, scientists and practitioners are continuously seeking key factors and characteristics that can identify potentially successful soccer players [13]. Research has revealed that technical, perceptual, psychological, physiological, and anthropometric factors must all be highly developed in order to reach an elite performance level [24]. Furthermore, it is well known that aspects such as growth, maturation, genetics, environment, and training each influence the developmental process towards sports expertise [17, 25]. Isolating and quantifying each of the different factors contributing to total performance in soccer is therefore a crucial yet extremely difficult task [14].

The identification and development of talented soccer players often rely on the empirical observations of coaching staff and scouts; however, previously published research underscores the need for supplementing such intuitive opinions with scientific observation [25]. A scientific perspective is helpful in providing practitioners with some objective measures of an athlete's development through predictable stages [25]. It has also been emphasized that, due to the complexity of both soccer and the talent process in general, the approach to understanding talent development in soccer should be multidisciplinary [14]. Such an approach has already proven itself capable of both identifying talented players and consistently distinguishing between elite and sub-elite players [14]. However, it remains unclear whether a multidisciplinary approach can draw accurate distinctions between players who have already been selected and included in systematic training [17, 25]. Importantly, when evaluating available information regarding

talent development in soccer, one must be sure to take into consideration that the majority of published data concern male players. Hence, the relevance of existing knowledge is open to debate, given the present aim of isolating and understanding the developmental process towards becoming an elite female soccer player.

In a multidisciplinary approach to talent identification in soccer, measurements of physiological factors should be included. $VO_2$max in female soccer players has been shown to vary between 48.4 to 55.0 $ml \cdot kg^{-1} \cdot min^{-1}$ [3, 5, 9, 11, 21]. Different results are related to different playing positions on the team, with midfielders scoring the highest and defenders (except for keepers) scoring the lowest. Similar findings have appeared in studies of younger female players [6]. Such positional differences have also been found with anthropometric characteristics in female soccer players. Even if there is a lack of significant findings, available data [9, 12, 20] still indicate a trend in observations that resembles documented findings in male soccer players, where goalkeepers and defenders are determined to be, on average, both heavier and taller than players in other positions.

The lack of knowledge concerning the female soccer player, and especially the young, talented female soccer player, has been previously emphasized elsewhere [25]. In a multifaceted sport such as soccer, it can be difficult to recognize the necessary prerequisites to achieving a given level of expertise. Therefore, it may prove helpful to find some objective reference points in accordance with developmental stages, in order to aid in the detection and development of future elite female soccer players. Hence, the purposes of this study were to identify and establish aerobic capacity and anthropometric characteristics of elite-recruit female soccer players, as well as to examine whether there are systematic differences between players assigned to different playing positions.

## MATERIALS AND METHODS

### Experimental Approach to the Problem

In order to identify and establish normative physiological and anthropometric data with the current cohort, we conducted tests of maximal oxygen consumption ($VO_2$max), anaerobic thresholds (AT), body mass, and stature. These data were also used for the investigation of possible systematic differences across playing positions. All measures were conducted 3 weeks into pre-season training at the Department of Sports laboratory at the University of Nordland in Norway.

### Participants

Thirty-two young, well-experienced (with a mean participation in organized soccer training of 8 ± 3 years) elite-recruit female soccer players, aged 17.4 ± 2.4 years, volunteered to take part in this study. The group consisted of 11 defenders, 8 midfielders, 10 attackers, and 3 goalkeepers. At the time of the testing, all participants played in the Norwegian 3rd senior division and took part in organized training 8.0 ± 2.0 hours per week, on average. Before taking part in the study, each player was familiarized with the testing protocol. All of the subjects involved in this study, including the club, the participants, and the parents of any participants under 18 years of age, approved the use of the depersonalized data presented here. Further, this study was conducted in accordance with the Helsinki Declaration and was approved by the local ethics committee at the University of Nordland.

### Warm-up Protocols

Body weight was measured using an electronic Precision Health Scale, ProFIT/IntelliSCALE model UC-321 (A&D Medical, San Jose, California, USA). Stature was attained using a wall-mounted stadiometer (KaWe Medizintechnik, Asperg, Germany). A lactate pro analyzer, model LT-1710 (ARKRAY, Inc., Kyoto, Japan), was used for the Anaerobic Threshold (AT) measurements. Furthermore, for the oxygen consumption test, we used a SensorMedics model VMAX29 (VIASYS Healthcare Respiratory Technologies, Yorba Linda, California, USA) connected to a PC (Intel dual-core) with the aid of a Vmax Program Manager (IVS-0101-12-7). The treadmill used in this study was a Rodby model RL 3500 (Rodby Innovation AB, Hagby, Sweden). Heart rate was monitored with the help of a Polar pulse transmitter T31 (sampling at 0.2Hz) and a polar pulse clock S610i (Polar Electro OY, Kempele, Finland).

### Testing Setup

All measures of body mass and stature were conducted while the participants were wearing minimal clothing. The results were rounded to the nearest 0.1 kg and 0.05 cm for weight and stature, respectively. Body mass index (BMI) and reciprocal ponderal index (RPI) were later calculated according to a protocol outlined by Nevill et al [13]. To establish aerobic capacity, all players underwent treadmill tests of AT and maximal oxygen consumption ($VO_2$max). The test-protocol, designed to measure AT, consisted of 5-7 increases in speed of 1 km/h every fifth minute. Before each speed elevation, blood lactate was taken by a finger stick and analyzed. A lactate level of 4.0 $mmol/L^{-1}$ (OBLA), as first introduced by Sjödin & Jacobs [18],

was used to define AT. In this study, AT is documented as the velocity level at anaerobic threshold (vAT) and as a percentage of maximum heart rate at anaerobic threshold (%HRAT). After the AT test, the participants were instructed to take a 10 minute recovery break before undergoing the $VO_2$max test. This test was conducted using a continuous incremental protocol with load increases every 30 s and with a total duration of 5-6 minutes. $VO_2$max is defined here as the average of the two highest oxygen values, and the exact criteria used to determine $VO_2$max involved capturing the moment when a plateau in oxygen consumption was observed with still increasing speed [19]. $VO_2$max results are expressed as the oxygen uptake in millilitres per minute per kilogram of bodyweight ($VO_2$max /ml·kg$^{-1}$·min$^{-1}$/) and as the velocity at $VO_2$max ($vVO_2$max).

### Statistical Analysis

The resulting data for all the examined groups were analysed with a histogram plot, and the normality of distribution was tested using Shapiro-Wilk's test. Levene's test was utilised to examine the equality of variances across the groups. Then, descriptive statistics were calculated and reported as mean ± standard deviations of the mean (SD), for each playing position group and for each anthropometric and physiological variable. If the data followed a normal distribution, the differences in the anthropometric characteristics between the groups were compared using a one-way ANOVA, followed by a Tukey post hoc test. If the data were not found to follow normality, the non-parametric Kruskal-Wallis test was used, followed by the Mann-Whitney test. The level of significance was set at $P \leq 0.05$ for all the statistical analyses. If differences were detected, a Tukey post hoc test was assessed to determine which playing positions were expressing these differences. All of the statistical analyses were carried out using SPSS 17.0 for Windows (SPSS Inc., Chicago).

## RESULTS

In exploring the data, $vVO_2$max and %HRAT were found not to be normally distributed within the groups ($P \leq 0.05$). All of the other variables in this study were normally distributed. The Levene's test did not show any statistically significant differences across all of the groups' variances. Consequently, the differences in the anthropometric characteristics were also examined using the Kruskal-Wallis test for $vVO_2$max and %HRAT, and a one-way ANOVA was applied for $VO_2$max, vAT, BMI, RPI, body weight, and stature.

**Table 1**. The mean (±SD) results of $VO_2$max, $vVO_2$max, vAT, % HR AT, BMI, RPI, Body weight and Stature for all groups, and comparison between groups.

| Variable | Defenders | | Midfielders | | Attackers | | Keepers | | Between Groups differ. |
|---|---|---|---|---|---|---|---|---|---|
| | mean ± SD | 95% CI | mean ± SD | 95% CI | mean ± SD | 95% CI | mean ± SD | 95% CI | P-Value |
| **$VO_2$max** (ml·kg$^{-1}$·min$^{-1}$) | 52.1±3.6 | 49.7-54.5 | 53.8±5.5 | 49.2-58.4 | 53.0±5.0 | 49.4-56.6 | 48.7±4.6 | 37.2-60.2 | 0.431 |
| **$vVO_2$max** (km/h) | 13.8±1.0 | 13.1-14.5 | 14.4±0.6 | 13.8-14.9 | 14.0±1.0 | 13.2-14.7 | 12.8±1.0 | 10.2-15.4 | 0.105 |
| **vAT** (km/h) | 9.2±0.9 | 8.5-9.8 | 10.0±0.6 | 9.5-10.4 | 9.3±1.1 | 8.5-10.1 | 7.9±1.1 | 5.2-10.7 | 0.032* |
| **% HR AT** (bpm) | 85.2±7.3 | 80.3-90.1 | 89.3±5.0 | 85.1-93.4 | 86.5-5.2 | 82.8-90.3 | 87.3±5.3 | 74.3-100.4 | 0.516 |
| **BMI** (kg·m$^{-2}$) | 22.1±1.7 | 20.9-23.3 | 20.7±1.9 | 19.1-22.3 | 20.5±2.2 | 19.0-22.1 | 24.2±0.5 | 23.0-25.3 | 0.020* |
| **RPI** (cm·kg$^{-0.33}$) | 42.9±1.3 | 42.1-43.8 | 43.6±1.3 | 42.5-44.7 | 44.1±1.6 | 43.0-45.2 | 41.4±0.6 | 40.0-42.8 | 0.026* |
| **Body weight** (kg) | 61.5±4.9 | 58.2-64.7 | 56.0±6.3 | 50.7-61.3 | 58.0±7.0 | 53.0-63.0 | 65.6±5.1 | 52.9-78.3 | 0.076 |
| **Stature** (cm) | 167.8±0.0 | 164.1-169.6 | 164.4±0.1 | 160.0-168.8 | 168.0±0.1 | 163.8-172.2 | 164.7±0.1 | 149.5-179.8 | 0.473 |

* = p≤0.05

Differences in vAT, BMI, and RPI were observed between groups (Table 1). Furthermore, a suspected difference was also observed in body weight. Investigation of the data reveals that there was a statistically significant difference between midfielders and keepers ($P \leq 0.05$) in both vAT and BMI (Figure 1 & 2), as well as between keepers and attackers ($P \leq 0.05$) in BMI and RPI (Figure 2 & 3). The suspected differences in body weight were found to be absent and hence judged to be false.

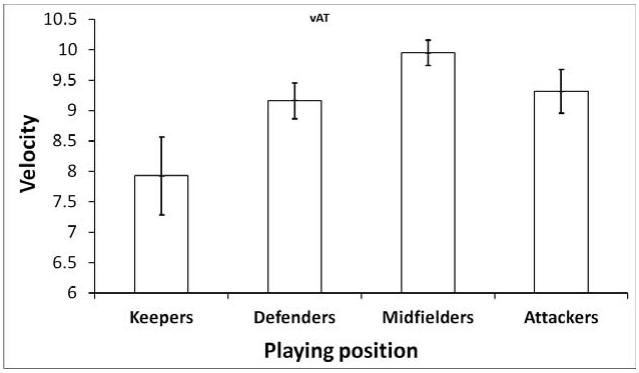


**Figure 1**. Mean and standard error of the mean (SEM) of the players velocity at anaerobic threshold

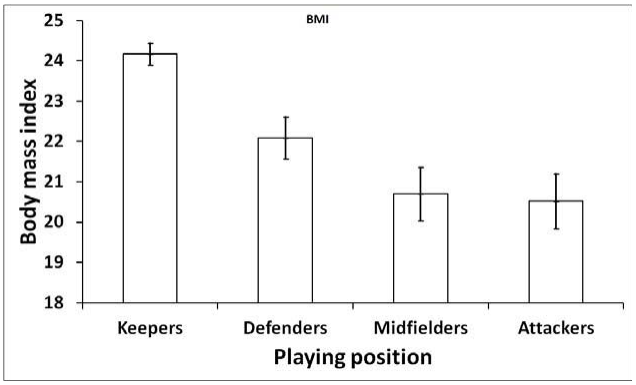


**Figure 2**. Mean and standard error of the mean (SEM) of the players BMI

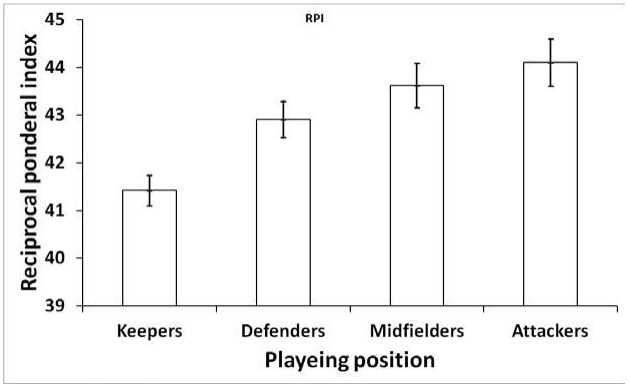


**Figure 3**. Mean and standard error of the mean (SEM) of the players RPI

## DISCUSSION

The main aim of this study was to identify and establish aerobic capacity and anthropometric characteristics of elite-recruit female soccer players. Further, the second aim was to examine if there were any systematic differences between players assigned to different playing positions.

### AEROBIC CAPACITY AND ANTHROPOMETRIC CHARACTERISTICS

Aerobic capacity has been identified as one of the key factors leading to high performance results in soccer [25]. The elite-recruit female players in this study achieved levels of oxygen consumption between 48.7 and 53.8 $ml \cdot kg^{-1} \cdot min^{-1}$. Compared to previously published data within female soccer studies, the present results were lower than what had been reported among elite female players [8, 9] and among Danish female national players [11]. However, the present $VO_2max$ results were somewhat higher than those reported within studies of English [4] and Australian [21] female national players, as well as both Canadian female university players [15] and Italian Division 1 female players [5]. It should be noted, however, that our study consisted of younger players; yet, previous research shows only minor differences between adult versus younger soccer players in $VO_2max$, when this measure is expressed relative to the player's body mass [1].

Research shows that soccer players' aerobic capacity is competition-level dependent. Thus, measurements of maximal oxygen consumption could be a criterion for detecting a successful future player or team [19]. In a study by Jankovic et al [10], two groups of soccer players, aged 15–17, were compared. One of the groups was found to be successful at a later stage in development while the other was not. The results indicate that measures of fitness, such as $VO_2max$, positively predict the group that will become successful based on better performance levels.

The results in running speed at $VO_2max$ (13.75 km/h) and AT (9.1 km/h), within the participants in this study, were slightly lower than previously published data onelite female soccer players [9]. Moreover, based on our review of the existing literature, these measures had only been reported once previously within female soccer studies even though they were elsewhere considered as important determinants of endurance capacity [7].

A link between anthropometric characteristics and performance in soccer has been proven to exist, and therefore, it is plausible to utilise such characteristics to direct the process of identifying talented players [25]. The present study produced mean values for the group as a whole of 21.87 $kg \cdot m^{-2}$, 43 $cm \cdot kg^{-0.33}$, 60.27 kg, and 166.22 cm for BMI, RPI, body weight, and stature, respectively (Table 1). The current participants were therefore highly comparable to elite Norwegian female soccer players [9], female university players [15], and both Danish [11] and English [4] female national team players. However, while they had a slightly lower mean body mass and stature than the Danish players, the present players appeared heavier than both Spanish female first division [12] and Australian female national soccer players [21].

### POSITIONAL DIFERENCES

No differences in $VO_2max$ measurements were observed between playing positions. A similar lack of positional difference had also been found by Todd et al [20] in female English championship players and by Wells & Reilly [23] in female university players. This equivalent finding could be documenting what has been previously speculated elsewhere, namely, that $VO_2max$ is not a sensitive enough parameter to differentiate between players [20]. Furthermore, the absence of differences in aerobic capacity may be due to a lack of individualization in the training programs of different playing positions [22]. This theory may explain our findings, given that our examination and testing of athletes occurred during the early preseason. Also, even if a fitness variable, such as oxygen consumption, has proven capable of distinguishing between elite and non-elite young soccer players, it remains to be seen whether such fitness variables possess the sensitivity to distinguish between players who have already been selected onto an elite-recruit soccer squad [25]. Regarding running speed at $VO_2max$ and AT, the only apparent differences between playing positions were that keepers ran significantly more slowly than midfielders and attackers at both $vVO_2max$ and vAT (Figure 1).

Concerning the findings of anthropometric characteristics, this analysis revealed a significantly higher BMI among keepers as compared to midfielders and attackers (Figure 2). Also, the RPI was found to be lower among keepers compared to midfielders and attackers (Figure 3). These results could possibly be explained by the findings of Rienzi et al [16]. These authors disclosed a relationship between the match work rate and anthropometric measures in soccer. It is probable that the keepers who participated in this study tended to perform less running than the attackers and the midfielders during both practice and matches and thus had a lower work rate in general.

Clearly, there may be some limitations behind the findings in this study. First, the information about the players' weekly work rate at the time of the testing was not accessible. Such information would probably have made it easier to interpret our findings. Second, the low number of players participating in the study could also call into question the strength of our results. However, when studying elite performers, and

especially when conducting laboratory testing, it is not easy to gather large samples. A third, previously acknowledged, limitation may be the timing of the data collection. Three weeks into preseason training is traditionally the period when Norwegian soccer teams prioritize training their members in general attributes rather than specific qualities. Finally, the use of BMI as a measure of body composition among sports performers is also a possible weakness of this study. BMI does not distinguish between fat and fat-free mass; therefore, we cannot know for certain whether a high BMI is the result of abundant adipose tissue or muscle mass.

## CONCLUSION AND PRACTICAL APPLICATION

Current results indicate that the subjects, taken from a group of elite-recruit female players, performed comparably well versus elite international female soccer players in terms of their aerobic capacity tests. It also appears that their anthropometric characteristics were comparable as well. Concerning positional differences, we found that the running velocity of keepers was significantly lower than that of midfielders and attackers, based on both the anaerobic threshold test and the test of maximal oxygen consumption. Furthermore, within the $VO_2$max measurements, no differences were observed across playing positions, and a higher BMI and lower RPI in keepers compared to attackers and midfielders were the only anthropometric differences found. No other significant differences between playing positions were identified amongst the participants in this study. Previous research had revealed that there were several positional differences amongst soccer players based on physiological and anthropometric variables [2]. Earlier studies had also shown that results of young, talented players often correlated with research findings at the elite level [Pena Reyes, 1994, in /25/]. Nevertheless, a large number of the results in the present study do not accord with these expectations. Some possible limitations behind our findings have been mentioned. However, as the main aim of this study was to establish normative data within a field that is still characterized by paucity of information and knowledge gaps, we conclude that the various limitations will have little impact, and that our data remain a significant addition to the field.

Based on our findings of lacking positional differences in aerobic capacity, it is recommended that coaching staff implement regular testing programs to monitor current players' physical development, given that aerobic capacity is claimed to be one of the most important physiological factors behind soccer performance, and that the physiological demands placed upon elite soccer players have been proven to vary between different playing positions. In constructing a multifactorial assessment of talent development in soccer, objective information based on scientific measurements can be crucial as it increases the comprehension of the individual players' capabilities by the coaching staff. Thus, attention to scientific knowledge and measurements of player performance can enhance the coaches' ability to design optimized training programs for young, talented players, and ultimately will support their ability to master the different positional demands within elite soccer.

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**Study 3 in full text**

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# THE EFFECT OF 40 M REPEATED SPRINT TRAINING ON PHYSICAL PERFORMANCE IN YOUNG ELITE MALE SOCCER PLAYERS

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**Abstract** The purpose of this study was to investigate the effect of eight-week repeated sprint training program on maximum sprinting speed, endurance sprinting speed, jump height and the ability to repeat and recover from high-intensity exercise (Yo-Yo IR1). Fifteen young, well-trained, elite male soccer players aged (±SD) 16.3 ±0.5 years, body mass 68.1 ±9.4 kg, and stature 178.5 ±7.3 cm, volunteered to participate in this study. All subjects were tested on 40 m sprint, 10x40 m repeated sprint, 3–6–9 agility with a 180° turn, countermovement jump (CMJ), squat jump (SJ), and Yo-Yo IR1 test. Subjects were randomly assigned to one of two groups: a training group and a control group. The training group followed a repeated sprint training program twice a week. The results indicate significant improvement within the training group from pre- to post-test in 10x40 m repeated sprint time (-0.29 s), 40 m sprint time (-0.33 s), 0–20 m sprint time (-0.19 s), 20–40 m sprint time (-0.15 s) and CMJ (1.3 cm). The control group results showed notable improvements in 0–40 m sprint time (-0.11 s), 10x40 m repeated sprint time (-0.09 s) and 0–20 m sprint time (-0.10 s). A comparison between groups indicates that there were marked differences between the two groups in 40 m sprint time (-0.22 s), 10x40 m repeated sprint time (-0.20 s) and 20–40 m sprint time (-0.15 s). We concluded that repeated sprint ability is trainable and the larger improvement within the training group as compared to the control group could be explained by the extra weekly repeated sprint training.

***Key words:*** RSA, CMJ, YoYo-IR1, recovery, training load

## INTRODUCTION

Research indicates that physical performance in soccer depends on various characteristics [4]. Specifically, endurance, strength, speed, power and agility must all be well developed in order to achieve a high performance level in soccer [12, 13, 19, 23]. Soccer match activities cover a range of intensities from low through moderate to high [19, 25]. Hence, a well-developed aerobic energy delivery system is important as it can assist players to maintain high-intensity and total work, and also help them to adjust the distance covered at low intensities so they perform at higher intensities when the game demands [5, 9, 24, 32]. Previous research has revealed that the most successful teams in modern soccer have the ability to perform and repeat high-speed actions more often than less successful teams [14]. These actions have been reported to characterise the crucial moments of a soccer match (e.g. scoring, winning position of scoring or likewise losing important defensive position) [26]. Furthermore, high-speed running and sprinting activities during a soccer match are proven to relate both to the ability to repeatedly sprint and the Yo-Yo IR1 test performance [1, 17, 22]. Such a merging relationship could be caused by both the similarities in the energy production of the two activities [1, 5, 8] and the concurrent demands on a certain degree of muscular power [8].

Analyses of elite soccer matches show that a player's sprint actions during a match can be categorised into actions of acceleration, deceleration, maximal speed and agility (alternation in the direction of motion) [19, 25]. Further analyses reveal that high-speed sprinting actions represent 1-11% of the total distance covered during a soccer match [19, 21, 29]. The majority of players conduct short sprints (2-4 s) every 60-90 s depending on the role and position of the player [4, 6, 26, 33, 34]. Hence, the duration of these high-speed sprinting actions highlights a major demand on acceleration speed. However, as sprints in soccer mainly start while the players are already running, the demand for maximum speed (flying speed

above 20 m) can be high as well [19, 26, 29, 34]. The fact that the distance covered and the amount of high-intensity running and repeated sprinting decrease from the first to the second half of a soccer match [18, 21] suggests a high demand on speed endurance. Thus, the practice of repeated sprints (< 10 s) with short breaks that allow for near full recovery (30-120 s) is required to maintain soccer players' sprinting speed over time [2, 3]. An improvement in running speed has been observed following speed endurance training combined with resistance training [11]. Such training has previously been reported to be linked to an enhanced anaerobic metabolism [8, 14], fibre hypertrophy and beneficial neural adaptations [10, 29], and an improvement in the ability to store elastic energy in leg extensors [15, 20]. However, to date, the effect of specialised repeated sprint training stimuli, which do not involve strength, plyometric or agility training, on soccer players' repeated sprint ability (RSA) has not been explored except in one study [31].

Consequently, the main purpose of this study was to investigate the effect of an eight-week specialised repeated sprint training programme on elite junior soccer players' RSA. A secondary purpose of the study was to examine if this repeated sprint training programme would have any effect on other physical performance abilities such as Yo-Yo Intermittent Recovery test Level 1 (Yo-Yo IR1), 40 m maximum sprinting speed, agility, countermovement jump (CMJ) and squat jump (SJ).

## MATERIALS AND METHODS

### SUBJECTS

One team of eighteen young, well-trained elite male soccer players who volunteered to participate in this study. Three subjects dropped out and the study continued with fifteen subjects aged 16.3 ±0.5 years, body mass 68.1 ±9.4 kg, and stature 178.5 ±7.3 cm. The subjects trained for 12.4 ±2.5 hours per week and their team played among the four best junior teams in the country. All participants gave their voluntary and informed written consent approved by their parents, and the study was approved by our University Committee.

### INSTRUMENTS AND TESTING SETUP

The stature was measured using a wall-mounted stadiometer (KaWe Medizintechnik, Asperg, Germany); jump height was estimated using force platform-based determinations of impulse and velocity at take-off. The force platform used was an AMTI model OR6-5-1. The data were amplified (AMTI Model SGA6-3), digitised (DT 2801), and saved to a stationary computer (PC Pentium 4 running Windows XP) using the special software program, Biopack MP 100. The agility sprint 3–6–9 m with a 180° turn, 40 m maximal sprints and repeated sprint were measured on artificial grass in an indoor soccer stadium using Newtest Powertimer 300s infrared photocells. The photocells were connected to a laptop (PC Pentium 3 running Windows XP) using PowertimerPC, a special program that measures time to the nearest 0.001 s. The Yo-Yo IR1 test was conducted on an indoor basketball court following the procedure previously described by Krustrup et al [17]. A CD-player (DC 1015, Denon Brand Company, Japan) with an amplifier (F590ES) and loudspeakers (SS-E420, Sony Corporation, Japan) was used to play the Yo-Yo IR1 CD track. Two digital video cameras (SDR-H80, Panasonic Corporation, Japan) were used to record the Yo-Yo IR1-test in order to maximise objectivity when analysing the results.

The subjects were matched according to their 40 m sprint time from the pre-test. Then they were randomly assigned to one of the two groups: the training group (n=8) and the control group (n=7). The study took part in the pre-competition phase of the subjects' training program and ended 13 weeks before the start of the season; the duration of the pre-competition period was 26 weeks. The length of the mesocycle was eight weeks. Each test round was conducted on two consecutive days with no training in between. On test day one, 3-6-9 m agility with a 180° turn, 40 m maximal sprint, and 10x40 m repeated sprint were measured; on test day two, countermovement jump (CMJ), squat jump (SJ), and Yo-Yo IR1 test performance were assessed.

### TESTING PROCEDURES

To familiarise themselves with the tests, the subjects completed a training session on the testing procedure one week prior to the pre-test.

On the first day of the pre-test, stature was measured before the subjects started with a 15 min general warm-up running at 60-70% of maximum heart rate, which ended with 4-5 accelerations over 50 m. Next, 3-6-9 m agility with a 180° turn and maximum running speed over 40 m were tested; a 5 min recovery was allowed between each of the tests. On both agility and 40 m sprint, the subjects were allowed three attempts each, with at least 3 min recovery between attempts. The 3-6-9 m agility with a 180° turn test used in this study involved positioning three lines on the field: one at 3 m, 6 m, and 9 m each. A photocell was placed at the start/finish line. The subject would sprint to the first line (3 m) and touch it with his foot, do a 180° turn and sprint back to the starting line, touching it with his foot again. Next, the subject would sprint to

the second line (6 m) and repeat the procedure described above; finally, the subject would do the same with the third line (9 m) and sprint back to complete the test by crossing the start/finish line. The timer started when the subject passed the photocell at the start/finish line (time zero) and stopped when the subject passed the photocell after finishing the last run. In the 40 m maximum sprint test, the subjects started from a standing position by placing the front foot on the starting line, and when the test leader gave the signal, the subject started the sprint to the finish photocell (40 m). The time started automatically when the subject broke the beam from the first photocell, placed at the starting line (time zero), and stopped when he passed the photocells at both 20 m and 40 m. Times were measured for the 0-20 m sprint and the 20-40 m sprint. The best results were retained for analysis. The endurance sprinting time test was measured by 10x40 m maximum sprints with 60 s recovery between each sprint, using the same procedure as in the maximum 40 m sprint. The subjects were asked to sprint as fast as possible in each run. The mean time for the 10 sprints was used for analysis as it had been described as a good indicator of a player's ability to perform several sprints [30].

On the second day of the pre-test, the subjects started with the same warm-up procedure as described on the first pre-test day. The subjects were then asked to complete the CMJ and the SJ tests before the Yo-Yo IR1 test. The CMJ was performed by the subject standing on the force platform with the plantar part of the foot in contact with the ground, hands on hips; from an erect standing position with a knee angle of 180°, a countermovement was performed until the knee angle decreased to approximately 90°; an immediate jump followed. The SJ test was performed from a semi-squat position with no countermovement. At the start, the knee was restricted to approximately 90°, with the plantar part of the foot in contact with the ground. The hands were on the hips and the trunk was erect. Next, the subject would jump immediately. On both CMJ and SJ, three attempts each were allowed with at least 3 min recovery between attempts. The best result from both jumping tests was retained for analysis.

The Yo-Yo IR1 test started after the test leader had measured and marked the running lanes with cones to 2 m width and 20 m length, and a recovery area, where cones were placed 5 m behind the finishing line. Then the Yo-Yo IR1 CD (the soundtrack) and the CD player were checked (by timing of the intervals) to ensure the soundtrack would be played at the right speed [17] between the sound signals (Beep). Then, the Yo-Yo IR1 test was conducted by two experienced test leaders who were responsible for making sure that the participants fulfilled the testing criteria according to the procedures described by Krustrup et al [17]. Verbal encouragement was given from both test leaders and team coaches prior to and continuously during the test, with the purpose of motivating the participants to work to exhaustion.

### The Training Intervention

Both groups in this study performed Nordic hamstring exercise, balance training (ankle strength on balance board), sit-ups, the plank, push-ups and the alternating back and arm rise twice a week during their regular soccer team training. Furthermore, the control group was instructed to continue with the team's original training plan. The training group completed two extra training sessions with repeated speed training. The training program completed by the training group included sprinting four sets of 5x40 m with 90 s recovery between repetitions and 10 min recovery between sets. The training was conducted every Monday at 10:00 AM and every Thursday at 06:00 PM. The team had soccer trainings on Mondays, Tuesdays, Wednesdays and Fridays. Before the speed training, the subjects completed both general and specific warm-up. The participants had to complete at least 90% of the training period and had to be able to complete all the tests to be included in further analysis.

### Statistical Analysis

Raw data were transferred to the SPSS 16.0 for Windows and Microsoft Excel for analysis. The normality of the data was examined by assessing the Shapiro-Wilk test on all measured variables in this study for both groups; the results indicated that all measured variables followed normality. Therefore, to detect differences in measurements between the pre- and post-tests, the paired sample t-test was performed to evaluate the difference in means between the paired samples (within group). To test for a difference in means between groups, the independent sample t-test was assessed. In order to determine the effectiveness of the applied RSA training, the effect size (Cohen's *d*) was calculated according to Rosnow and Rosenthal [27]. Furthermore, to determine whether the effect size was trivial ($d$>0.2), small ($d$=0.2-0.6), moderate ($d$=0.6-1.2), large ($d$=1.2-2.0), or very large ($d$>2.0), the scale developed by Batterham and Hopkins [7] was used. Differences were considered significant at $P \leq 0.05$, and the results were expressed as means and standard deviations. The 95% confidence interval was also calculated for all measurements.

## RESULTS

Differences within and between groups in a variety of physiological measures are shown in Table 1. The results indicate that there were significant improvements within the training group from pre- to post-test in 10x40 m repeated sprint time, 40 m sprint time, 0–20 m sprint time, 20–40 m sprint time and CMJ. The results

also showed significant improvements within the control group in 40 m sprint time, 10x40 m repeated sprint time and 0–20 m sprint time. A comparison between groups demonstrates statistically marked differences between the two groups in 40 m sprint time, 10x40 m repeated sprint time and 20-40 m sprint time.

**Table 1**. Mean results of 10x40m repeated sprint, 40m sprint, 20m acceleration, 20m top speed, SJ, CMJ, Yo-Yo IR1 , agility and body mass between and within groups from pre to post-test ( ±SD)

| | Training-Group | | | | Control-Group | | | | Between Groups differences | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Pre-test | Post-test | Change | 95% CI | Pre-test | Post-test | Change | 95% CI | TG | CG | Difference | 95% CI | E.S. |
| 10x40 m (s) | 5.92 ±0.26 | 5.63 ±0.15 | -0.29 ±0.13 | -0.39 to -0.19** | 5.84 ±0.27 | 5.74 ±0.25 | -0.09 ±0.03 | -0.12 to -0.07** | -0.29 ±0.13 | -0.09 ±0.03 | -0.20 ±0.05 | -0.30 to -0.09** | 2.1 |
| 0-40 m time (s) | 5.82 ±0.27 | 5.49 ±0.18 | -0.33 ±0.13 | -0.44 to -0.22** | 5.69 ±0.25 | 5.58 ±0.23 | -0.11 ±0.06 | -0.17 to -0.06** | -0.33 ±0.13 | -0.11 ±0.06 | -0.22 ±0.05 | -0.34 to -0.10** | 2.1 |
| 0-20 m time (s) | 3.29 ±0.14 | 3.10 ±0.08 | -0.19 ±0.10 | -0.27 to -0.10** | 3.22 ±0.17 | 3.11 ±0.12 | -0.10 ±0.06 | -0.16 to -0.04** | -0.19 ±0.10 | -0.10 ±0.06 | -0.08 ±0.04 | -0.18 to 0.01 | 1.1 |
| 20-40 m time (s) | 2.53 ±0.16 | 2.39 ±0.14 | -0.15 ±0.08 | -0.21 to -0.08** | 2.46 ±0.11 | 2.46 ±0.13 | -0.00 ±0.05 | -0.05 to 0.05 | -0.15 ±0.08 | -0.00 ±0.05 | -0.15 ±0.03 | -0.22 to -0.07** | 2.2 |
| CMJ (cm) | 31.1 ±2.6 | 32.3 ±2.6 | 1.3 ±1.2 | 0.28 to 2.27* | 33.0 ±5.1 | 32.1 ±5.4 | -0.9 ±2.6 | -3.23 to 1.49 | 1.3 ±1.2 | -0.9 ±2.6 | 2.2 ±1.0 | -0.03 to 4.32 | 1.1 |
| SJ (cm) | 30.9 ±3.5 | 31.8 ±1.7 | 0.9 ±2.0 | -0.81 to 2.59 | 30.7 ±4.8 | 30.2 ±5.5 | -0.5 ±2.5 | -2.85 to 1.80 | 0.9 ±2.0 | -0.5 ±2.5 | 1.4 ±1.2 | -1.12 to 3.96 | 0.6 |
| Yo-Yo IR1 (level) | 17.3 ±0.8 | 17.1 ±0.9 | -0.2 ±0.6 | -0.66 to 0.26 | 17.1 ±1.4 | 16.5 ±1.4 | -0.5 ±0.8 | -1.26 to 0.23 | -0.2 ±0.6 | -0.5 ±0.8 | 0.3 ±0.4 | -0.45 to 1.08 | 0.4 |
| Agility (s) | 9.29 ±0.24 | 9.19 ±0.22 | -0.10 ±0.15 | -0.22 to 0.03 | 9.50 ±0.47 | 9.42 ±0.49 | -0.08 ±0.23 | -0.29 to 0.14 | -0.10 ±0.15 | -0.08 ±0.23 | -0.02 ±0.10 | -0.23 to 0.19 | 0.1 |
| Body mass (kg) | 68.0 ±10.0 | 68.7 ±9.0 | 0.8 ±1.4 | -0.39 to 1.88 | 68.3 ±9.4 | 69.0 ±9.1 | 0.7 ±0.9 | -0.08 to 1.56 | 0.8 ±1.4 | 0.7 ±0.9 | 0.0 ±0.6 | -1.29 to 1.31 | 0.1 |
| * = p < 0.05, ** = p < 0.01, TG =Training-Group, CG= Control-Group, E.S.= Effect size (Cohen's *d*) | | | | | | | | | | | | | |

The effect size of the training program between the groups shows that even though there were no statistically significant differences between the groups in 0–20 m sprint time, CMJ and SJ, the effect of repeated sprint training on the training group was large and close to very large in 0–20 m sprint time and CMJ (Table 1).

## DISCUSSION

The observed improvement in the RSA within the training group is substantial, especially considering that the subjects trained soccer for 13 hours per week on average and only engaged in a specific speed training twice a week over eight weeks. Nevertheless, the results demonstrate that this type of training is effective, and that the RSA appears to be trainable using only a repeated sprint training program with no involvement of strength, plyometric or agility training. Previous research indicated that the improvement in the RSA could be due to a positive change in the anaerobic metabolic contribution [8, 14] and/or an improvement in the participants' ability to utilise the stored elastic energy in leg extensors caused by the negative and then positive work in leg extensors during repeated sprint training [14, 15, 20]. Furthermore, the subjects' limited previous experience in sprint training, combined with the timing of the study may also have contributed to the RSA improvement observed in the training group. Kraemer et al [16] reported that the basal concentration of testosterone significantly increased one week after the season, reflecting a dramatic reduction in total stress related to the season, which would cause a faster adaptation to training stimuli. On the other hand, the RSA improvement detected within the control group could be attributed to the timing of the study, as well as to the impact of players' daily soccer training [30]. These explanations could also apply to the improvement noted in the training group's 0-40 m sprint time; the split time shows that the improvement occurred in both 0-20 m and 20-40 m sprint times. Comparison with the control group reveals that the training group exhibited a considerably larger improvement in the 20-40 m sprint time (Table 1). Despite the fact that speed is believed to be a skill with a genetic quality, and less dependent on training [28], one could speculate from the results presented here that specialised training of running speed could result in an improvement in soccer players' sprinting speed. Similar results indicating a gain in acceleration following a similar but resisted sprint training programme have been reported [11].

Concerning jumping ability, the RSA training programme had a positive and significant effect on CMJ performance within the training group (Table 1). The control group, on the other hand, experienced no significant change in CMJ performance, which could be discerned from the very large SD within this group (Table 1). The lack of improvement within the control group CMJ could have been caused by not performing the two extra weekly training sessions of the training group, which may have affected the strength–velocity, force–time, or SSC contractile abilities of leg extensors. The improvement in CMJ reflects an enhancement (as with the RSA) in the ability to utilise the stored elastic energy and indirectly assists in the first phase of force–time curve initiated by the rate of force development (RFD) occurring in the first 180-250 ms in leg extensors within the training group. The improvement in CMJ could be further explained by findings from other studies where speed, leaping power and strength have been reported to affect each other if an improvement in any one of them occurs [29, 34]. Neither group experienced a statistically significant change in SJ.

No marked changes in Yo-Yo IR1 performance were observed within the training group in this study. This is in contrast to the results of Bravo et al [8] that revealed improved Yo-Yo IR1 performance following repeated sprint training. We speculate that the lack of Yo-Yo IR1 performance improvement within our training group could be due to the long breaks between the sprints in our training programme, resulting in

the aerobic energy production not being sufficiently triggered to cause any effect [1, 36]. No changes in Yo-Yo IR1 performance were detected in the control group.

No notable improvement in the performance of the 3-6-9 (m) agility test with a 180° turn was exhibited by either group. This was expected because the relationship between sprinting and agility had been shown to be weak, and the training methods used for enhancing agility and speed are specific and produce limited interactive effects [19, 35, 36]. This could be due to the differences in performing each skill – the RSA training programme used here involved only sprints in a straight line (closed skill), whereas agility often involves actions requiring change of direction and rapid start and stop [36].

## CONCLUSION AND PRACTICAL APPLICATION

In the present study, two weekly sessions of repeated sprint training (10.7% of the total training time) were only a small part of the subjects' total training load. However, the marked improvement observed within the training group compared to the control group could be explained by the extra repeated sprint training, confirming that the RSA is trainable. However, due to the fact that the results of this study demonstrate a positive effect on RSA, it would be of interest to repeat the study on elite soccer players from a higher division and examine whether it would lead to similar improvements.

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**Study 4 in full text**

**Dillern, Thomas**; Jenssen, Ole Ragnar N.; Ingebrigtsen, Jørgen. *Physical fitness and anthropometric characteristics of graduating Norwegian Police University College students.* European Journal of Policing Studies 2014; Volume 1(3) pp. 192-205

**Study 5 in full text**

**Dillern, Thomas**; Jenssen, Ole Ragnar N.; Lagestad, Pål; Nygård, Ørjan; Ingebrigtsen, Jørgen. *Arresting a Struggling Subject: Does the Forthcoming Police Officers' Physical Fitness have an Impact on the Outcome?* The Open Sports Sciences Journal 2014; Volume 7. pp. 2-7


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# Arresting a Struggling Subject; Does the Forthcoming Police Officers Physical Fitness have an Impact on the Outcome?

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**Abstract:** Handling a struggling subject has been pointed out as one of the maximal physical exertions of police work. However, the relationship between general physical fitness and the ability to manage an intractable subject is only scarcely examined. Therefore, the main purpose of this study was to examine how general physical fitness correlates with the forthcoming police officers' ability to handle in a simulated arrest handling test. Nineteen male police students voluntarily agreed to participate. Four physical tests were conducted (bench press, counter movement jump, hang ups and 3000 meter running test). Scores from these tests were converted into a physical test index (physical index). Further, a simulation of handling a struggling subject during arrest was conducted. The simulation contained two takedown tests and two self-defense tests. Scores from the arresting simulation tests were also aggregated in a performance score index (arrest index). Later, the two indexes were correlated. We found a large correlation 0.547 ($p<0.05$) between the physical index and the arrest index. We also found that age was largely and moderately correlated to the physical index ($p<0.05$) and the arrest index ($p<0.1$), respectively. Although the police officers handling of a struggling subject during arrest involves a skill component related to the executing of diverse impact methods, our findings clearly show that it is also about some form of physical capability. The present study therefore highlights the importance of physical fitness within the police force.

**Keywords:** Endurance, occupation, police, physical demands, physical performance, strength.

## INTRODUCTION

Modern police work imposes different requirements to the police officer than the previous officer had to cope with. New assignments have been given to the police, and communication and cooperation have become increasingly important to solve these tasks [1]. Thus, the operative officer spends much of the working day carrying out low intensity activity, and the occupation is therefore mainly described as sedentary [2]. However, due to regularly emerging episodes of high physical exertion the occupation can still be physically demanding. Such episodes are often occurring acute and can be stressful, critical and even life threatening for both the officer and the surrounding civilians [1, 3]. So even if the major part of the job can be executed independent of a police officers' physical fitness, some tasks still demand certain level of physical fitness to be handled and if the officer is not capable of managing these tasks as well, it can be questioned if he or she is capable of doing the job at all. Consequently, to ensure that the police officers are capable of performing their job some minimum requirements of general physical fitness ought to upheld. However, the relationship between general physical fitness and the ability to cope with physical tasks of police work is though not well known. It could thus be interesting to examine if general physical fitness affects how the police actually copes with a highly occupational specific task of physical exertion. In the everyday police job, the officer can come across a variety of physical demands and lifting, carrying, pushing, dragging, pulling and running are the most frequent physical tasks reported [4-11]. However, one of the most critical and stressful physical tasks of operative police work is getting control of a struggling suspect during an arrest [1, 6].

Even if the apprehension of a strongly intractable subject is not reported to occur frequently, it is described as the most commonly occurring maximal physical exertion in the profession [6]. Although the number of occasions reported is somewhat varying, this may be related to the inconsistencies in the content of the term "physical force" [12]. The term can be approached both broadly and narrowly, and can be described along a range according to its severity. When using a broad approach, the execution of physical force from police officers during arrest encounters is disclosed to appear in 21% and 27% [12] of all situations. In the present study, the term is narrowed and operationalized as arrest situations where physical force is applied to get control over an intractable subject, and further where the use of different kinds of weapons, pepper spray or handcuffing, or the use of

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**Table 1. Descriptive Data on the Participants (Mean ± SD) (n=19)**

| Variables | |
|---|---|
| Standing broad jump (m) | 2.55 (±0.2) |
| Pull ups (repetitions) | 15.1 (±4.6) |
| Bench press (kg) | 106.8 (±13.1) |
| 3000 m running test (min.sec) | 11.53 (±0.99) |
| Age | 25.3 (±2.1) |
| Stature (cm) | 181.5 (±5.5) |
| Body mass (kg) | 82.4 (±7.2) |
| BMI* | 25.0 (±1.48) |

*BMI (Body mass index) was calculated as $kg/m^2$.

only a firm grip on a subject is not included. When these demarcations are implemented, the police officers use of physical force drops substantially and is reported only to be executed in 4.7 % of all encounters [12]. The severity of these encounters can however not be questioned. Smolander [5] presented unpublished statistics from the Finnish National Board of Labor Protection where it was shown that 40 % of all occupational accidents in the Finnish police "*occurred during the arrest of and struggle with resisting subjects*" (pp. 295-296). This emphasizes the need for upholding some level of physical fitness to cope with such episodes.

The relationship between general physical fitness and the ability to manage the maximal exertion in the police occupation is though only scarcely examined. Some studies have yet been conducted. Wilmore and Davis [13] were the first who aimed to examine if physical fitness correlated with job-specific tasks and found that the handling of a simulated arrest situation correlated with general physical ability. Similar findings were reported by Greenberg and Berger [14] who conducted basic anthropometric and strength tests and compared the results with the performance in a competitive task. The task consisted of a competition between two individuals inside a 5 feet circle where the purpose was to push or pull each other out of the circle, and it was designed to embrace the physical abilities relevant to apprehend and restrain a resisting subject during arrest. Based on the results in the general tests of strength and anthropometry, Greenberg and Berger were able to predict the performance in the competitive task. However, these studies based their conclusions on the usage of machinery or on the use of a regression model to assess the arrest performance, to the best of our knowledge the implementation of a real struggling subject in the simulation has never been done previously. Therefore, the main purpose of this study was to examine if the forthcoming police officers general physical fitness affects their ability to handle a real struggling subject during an arrest simulation test. Additionally, a second purpose was to examine if the officers physical fitness and arrest handling were affected by their age and anthropometric characteristics.

## METHODS

### Participants

Thirty-nine male graduate students at the Norwegian Police University College were invited to participate in the study. The inclusion criteria in the study were that every student invited had to have completed three years of education at the University College, and during these years had finished mandatory courses related both to physical training and arrest handling. Nineteen students gave their voluntarily written consent to participate. The descriptive data of these students are presented in Table **1**. All of the participating students approved the use of depersonalized data, and the study was conducted according to the Helsinki declaration, and was also approved by the leadership of the University College.

### Experimental Approach to the Problem

To assess the relationship between general physical fitness and ability to perform in a simulated arrest handling situation, we used a descriptive correlative-explorative study design. Four physical tests were conducted (bench press, hang ups, standing long jump and 3000 meter running test), and scores from the different tests were converted into a physical test index (physical index). Further, a simulation of handling a struggling subject during arrest was conducted. The simulation contained two takedown tests and two self-defense tests. Scores from the four different tests of the arresting simulation were also converted into a performance score index (arrest index) and the two indexes were later correlated. All tests were carried out at the facilities of the University College. The physical fitness tests were performed in the sports facilities and the arrest simulation tests were carried out in a specially designed gym room with gymnastic mats on the floor. Further, age and anthropometric data were collected through a simple questionnaire. All participants (officers) had previously practiced the different tests, so measurement errors caused by learning effects were reduced.

### Procedures

#### *Physical Ability Tests*

To assess physical ability, all the officers were tested in a bench press test (1RM) to assess maximum upper body strength, a pull-up test to measure upper body strength endurance, a standing long jump test (SLJ) to evaluate explosive power and a 3000m running test to assess aerobic endurance. The strength and power tests were performed on the same day and the 3000 meter run was performed within 7 days after. Further, in the strength and power tests the students had two attempts, but in the 3000 meter run the students were only given one attempt. When two attempts were given, the best result was used for further analysis. The officers were instructed to individually prepare themselves to each of the tests, this also implying both a general and a specific warm-up. On all tests, the students were given a score according to their performance evaluated by minimum two experienced test leaders. The possible score for each test was between 0 – 60 points on a scale of 5 points interval and where a higher achieved score implies a better performance. Further, before testing, all the equipments included were calibrated.

**Bench Press**

The bench press test was performed on a smith machine (gym80 International, Multi Press Station 50 mm Plate Holder, Germany), using calibrated Olympic weights (Elieko, Competition, Sweden), and a 50 cm high bench. The officers lied in a horizontal position, and lifted as much weight as they could in one repetition maximum (1-RM). The execution started when the students held the weight bar with straight elbows, then they lowered the bar controlled until it touched the chest. At the lowest point the bar had to be held still for 0.5-1.0 second, before the students pressed the bar upwards again until a fully extension in the elbow joint. To get the test approved the shoulders and the gluteus muscle had to be in contact with the bench during the whole execution.

**Pull-ups**

The pull-up tests were performed on a beam. The starting position was hanging vertically with straight elbows grabbing the beam with pronated grip at shoulder width (+/- one hand width). On signal the officers started the execution by pulling them upwards until the chin was above the beam, and then they lowered themselves to the starting position again, and this procedure was repeated until exhaustion. The execution had to be carried out in a controlled manner, with no kipping, swinging or explosive movements. Further, in the lowest position the elbow joint had to be fully extended before the next repetition could be performed.

**Standing Long Jump**

The standing long jump was executed from a wooden box, which was 2 centimeters elevated above the floor surface. The officers stood with 1-2 centimeters of their shoe-tip outside the edge of the wooden box, and then performed a countermovement jump with double spring not allowed. The landing area was covered with a rubber mat and the length of the jump was determined by the back of the heel on the rearmost foot, which was powdered in magnesium before the jump to mark the landing point. The distance between the edge of the wooden box and the landing point was then measured.

**3000 Meters Run**

The 3000-meter running test was conducted on a standard track and field course with 400 meters rounds with a joint start of maximal twelve students in each heat. Spiked running shoes were not permitted. Time was recorded with an ECB1 (Emit, Norway) and emiTag timing chip (Emit, Norway).

***Arrest Handling Tests***

To assess the officers' ability to handle an intractable subject an arresting simulation was conducted. The simulation was carried out within two weeks after the physical tests and comprised four tests; a takedown - one on one, a takedown - two on one (two officers and one subject), a self-defense struggle with an opponent and a self-defense where the officer had to get himself of herself released from different strangleholds. The tests are developed to assess the Norwegian police students, as well as the active duty Norwegian police officers, ability to apprehend and maintain a resistant subject during an arrest encounter, and are created to meet the considered physical requirements necessary for this matter. Further, the tests represent all the legal impact methods that the Norwegian police officers can use under the execution of physical force, and can thus be regarded as instruments of both training and testing. Although some of the containing methods have their origin from the Norwegian police back in the 1920s, the entirety of these tests are established based on the work of 15 specialists in 2007 [8]. Additionally, to secure minimization of risk of injuries, on both the police officer and the suspect, the tests have also been evaluated and accepted by a medical specialist appointed by The Norwegian Medical Association (NMA). During the execution the performing police officers had to wear police uniform as they use in field. In all tests the opponents (subjects) were fellow students who matched according to gender, height and weight, which was considered to make the resistant from the subject comparable from test to test.

As in the physical tests the students were given a score based on their performance. However, as the physical test scores were based on objective measures, the scores in the arrest handling simulation were related to a performance assessment made by an evaluation committee. The committee consisted of two educated and authorized instructors who were well experienced. Further, the test scores were given by a six point scale (0-60 points with 10 points interval), where a higher achieved score implies a better performance. Comprehensive information about the execution of the different impact methods, as well as the standardized evaluation criteria, of the tests are described in Lie and Lagestad [15] and in "Guidelines for execution of Arrest Technique exam [22]. The different score levels were mainly related to the opponents degree of resistance (Table **2**). In the lowest score level, the opponent was inactive and as the level became higher the resistance from the opponent became increasingly tougher: gained more speed and force, reducing distance to the officer, sudden attacks and increased frequency. On the highest level, the situation was supposed to be as realistic as possible with heavy resistance from the opponent. The officer had then to counter-attack the opponent to get control over him, and subsequently to show that control was maintained until handcuff was ready to be put on [15]. Besides this the officers were assessed by their ability to uphold their timing, and have flow and dynamics, in their execution, further that they upheld balance, were able to intake a basic stand between impacts and that they continuously faced their opponent when practicable. Furthermore, the officers started all tests at the lowest level and had to have approved one level to be able to proceed to the next. When the officer did not perform well enough, the test was stopped and he got the score at this level. Although different score levels were achieved, the total test duration was seldom longer than 10 minutes for each officer.

**Takedown Tests**

The takedown - one on one consisted of two sequences; one where the student tried to take control of the opponent by pulling him or her forward, and one where the student

**Table 2. Opponents Degree of Resistance* Under the Different Arrest Handling Tests**

| Test Performed | Takedown Tests | Self-Defence Test: Release from Strangleholds | Self-Defence: Struggle |
|---|---|---|---|
| 0-30 points | No movement | Small amount of force in the grip. | Standing still holding a punch pad. |
| 40 points | Slightly movement in upper body and arms. Moderate resistance. | As above but slightly more force. | Moving around the officer in a moderate tempo on a distance between 2-4m. Sudden move towards the officer. |
| 50 points | Moderate resistance. Try to avoid the officer. | Moderate force in the grip and push or pull the officer moderately. | Same as above but faster movement. Shorter distance (1-2m). |
| 60 points | Move towards the police officer. Aggressive and threatening. | High rate of force in the grip, as well as in the pushing and pulling. | Full sparing fight |

* The table is based on the information from the document "Guidelines for execution of Arrest Technique exam" [23].

**Table 3. Pearsons' Correlations between the Investigated Variables. (n=19)**

| | Age | Stature | Body mass | BMI | Pindex |
|---|---|---|---|---|---|
| Age | | | | | |
| Stature | 0.076 | | | | |
| Body Mass | 0.086 | 0.724** | | | |
| BMI | 0.061 | 0.019 | 0.702 | | |
| Pindex | -0.536* | -0.029 | 0.040 | 0.069 | |
| Aindex | -0.448$^{\#}$ | 0.123 | -0.095 | -0.270 | 0.547* |

** p<0.01, * p<0.05, $^{\#}$ p<0.1. BMI: Body mass index, Pindex: Physical index, Aindex: Arrest index.

tried to take control by pushing the opponent backward. On each score level the approval was given when the opponent laid face down on the floor, with the student on top ready to put on handcuffs. The takedown – two on one consisted of the same procedures as one on one, but with an element of cooperation between the two students.

### Self-Defense – Struggle

In the self-defense struggle the students had to counterattack an attacking opponent by performing kicks and punches in different situations. At the three lowest levels the kicks and punches had to be executed towards a pad held by the opponent who as the level increased became more aggressive and moved quicker around. If the student reached the 60 point level he or she had to do a boxing battle against the opponent who now moved around and hit back.

### Self-Defense - Strangleholds

In the other self-defense test the student had to release him- or herself from four different strangleholds. In the first level the student had to come out of a soft stranglehold from an opponent standing still (30 points). At the second level the grip was stronger and the opponent moved a little backwards (40 points), and at 50 points the grip was even stronger and the opponent moved forwards. If the student reached the highest level (60 points) he or she had to release him- or herself from a very hard grip, also with closed eyes which it was not possible to see if the stranglehold came from the back or the front side.

### Statistics

SPSS 17.0 for Windows was used for data analyses. Both the physical fitness index and the arrest handling index were composed by summarization of the values from the four included variables. The Pearsons' product moment correlation coefficient (r) was used to calculate the correlation between the performance in the physical fitness index and the arrest handling index, and also to calculate the correlation between age and anthropometric characteristics and both these indexes. Magnitude of correlation coefficients was considered as trivial ($r<0.1$), small ($0.1<r<0.3$), moderate ($0.3<r<0.5$), large ($0.5<r<0.7$), very large ($0.7<r<0.9$) and nearly perfect ($r>0.9$) and perfect ($r=1.0$) [9]. Further, the shared variance (r2) was calculated to estimate the level of common variance between the respective variables. The $p<0.05$ level of significance was adopted for all statistical tests.

## RESULTS

The results (Table **3**) show a large correlation ($p<0.05$), and a shared variance ($r^2$) of ~30%, between the physical index and the arrest index. Further, we found a large negative correlation between age and the physical index ($p<0.05$) with a shared variance of ~29%, and a moderate negative correlation between age and the arrest index ($p<0.1$) with a shared variance of ~20%.

## DISCUSSION

In this study we found a strong correlation ($r$=0.547) between a general physical test index (physical index) and an arresting simulation test index (arrest index). Although causality is not scrutinized, we interpret this to indicate that some level of physical fitness could increase the ability to handle an intractable subject during an arrest encounter. To our knowledge, present method for assessing arrest handling has not been applied elsewhere. Similar findings however, as previously mentioned, were also reported by Wilmore and Davis [13] and Greenberg and Berger [14]. Thus, it seems likely that a relationship between general physical ability and the ability to apprehend a struggling subject during arrest exists. When a police officer faces an intractable subject the subject will in several manners attempt to avoid the officer's effort to get control over him or her. The subject is likely to do whatever necessary to escape, which also implies that physical force might be exerted by him or her. According to Anderson *et al.* [2], the subject can under these circumstances push, pull or even begin a fight with the officer, which again forces the officer to counterattack by applying the same methods. In fact, it was revealed by Anderson and his colleagues that police officers when struggling with an intractable subject had to push and pull the subject in 93 % of all incidents. Further, the severity of these episodes becomes clear when 72% of all occasions required medium to maximum physical effort from the officer to handle them. One possible explanation for our finding is the similarities in muscle activity between the general physical tests and the arrest handling test.

One of the main aims of the execution in the arrest simulation is to get the subject out of balance by pushing and/or pulling him/her [15]. Therefore, based on the execution of especially the pushes and the pulls during the apprehension of an intractable subject it is likely that the bench press and the pull-up tests represent characteristics of relevant muscle groups and can thereby be important factors when considering the ability to manage an arrest situation. Consequently, large muscle strength in the upper body, in particular in big muscles such as pectoralis major and latissimus dorsi, seems beneficial for police officers to uphold. Although Rhodes and Farendholtz [16] did not find strong correlations between pull-ups and push-ups and the handling of a struggling subject, this could be explained by their use of a static artificial body as the subject which makes the task somewhat unrealistic. For instance, their method excluded the possibility to differentiate the opponent's degree of resistance. This is one important element as the amount and extent of police officers use of physical force are proven to be highly related to the degree, or severity, of the resistance carried out by the subject. Terrill [12] reviled that when no resistance was shown from the subject during an arrest the officer ended up with use of physical force in approximately 20% of all encounters. On the other side, when subjects showed some form of resistance (although still not active – which was reported in too few cases to be included) 74.5% of the encounters required physical force from the officer.

Further, even though it is likely that the performances in the bench press and the pull up tests are the most influential factors affecting the arrest handling performance, the other tests included in the physical ability index might also influence. When the officer pushes and/or pulls the subject from a standing position, a higher strength and power capacity in the lower extremities are beneficial. To be able to exert physical force from the upper body the officer has to uphold a strong and balanced stance. Additionally, as the degree of resistance from the opponent increases with more, and quicker, movements and numerous sudden and unexpected attacks against the officer, the officer's ability to respond with powerful and rapid movements becomes increasingly important. Standing long jump is possibly not the most reliable method to measure power and strength in the lower extremities. The present execution is though almost identical to the execution of the free counter movement jump, with the only difference being the power-direction, a significant correlation has previously been proven to exist between the two [23]. It is therefore possible that also standing long jump had an effect on the outcome of the arrest handling. More, as the duration of the arrest simulation was up to 10 minutes it is also possible that the performance in the 3000 m endurance test is a factor that have to be taken into account. The endurance test mainly reflects aerobic capacity, but to some extent also anaerobic capacity [24], and higher endurance would make the officer better able to stay concentrated, focused, to move around, and to execute the necessary impact methods at the right time, especially as the duration of the test increases.

The officers' age was largely and moderately correlated to the physical index and the arrest index, respectively. These correlations were negative, where the aggregated performances in both indexes decreased with increased age. Relationships between decreased physical fitness and increased age are previously disclosed in the police force [1, 17]. Considering that critical situations, which demand high intensity physical involvement, do occur independent of the officer's age and physical fitness these findings are disturbing. A lowered physical fitness level related to increased age could seemingly have a negative impact on the result of the situation [3, 10]. Regarding stature, body mass and BMI correlated with the physical index and the arrest index, no significant findings were disclosed. To some extent this was surprising to us, especially the lack of correlation between stature and the performance in the arrest handling test. Even though we do not have much relevant data for direct comparison, it could be relevant to look at what is found in material arts, which in many ways are comparable to our simulated arrest test. It has been shown that the performance in material arts increases in relation to both increased body mass and a higher stature [18, 19]. Also Ghorbanzadeh *et al.* [20] found a significant correlation between stature and the performances among athletes in material art, and it was pointed that the advantages in having a high stature were due to a significant biomechanical benefit compared shorter competitors. Long upper and lower limbs imply a greater range to cover. The same benefit has been disclosed within the police as both a high stature as well as long arms were found to be advantageous in situations where the police had to use physical force [7, 21]. To be able to put people out of balance by coming from 'above' is an important factor when trying to cope with an intractable subject [15]. Further, greater body mass will make it easier to force people out of balance and make it more difficult for

the struggling subject to take physical control of police officers. Nonetheless, when this study did not find any correlations between stature, body mass and BMI and the arrest index, this may be explained by the initial matching of the officer and subjects in the study. In the test situation the opponents were persons who matched according to the officers' height and weight. This probably resulting in that the taller and the larger officers did not get the advantage as what can be expected under normal conditions.

## LIMITATIONS

When interpreting the findings of the present study some limitations have to be accounted for. First, arrest handling is assessed in an artificial context and it cannot be known for certain how well this simulation reflects real police practice. Second, the performance in the arrest simulation test is, to some extent, related to the technical execution of diverse impact methods, which not necessarily are directly dependent on physical capacities. Third, for future studies a higher N can be included. This will make it possible to separate the different tests of both indexes, to give a greater understanding of which parts that especially were related to each other. Fourth, the anthropometric characteristics are based on self-reporting through a paper scheme. Future studies could include more reliable methods for this matter.

## CONCLUSION

In the present study, we found a large correlation between police students' general physical capacity and their ability to handle in a simulated arrest test. To the best of our knowledge this is the first study to examine this relationship by the use of a real struggling subject to assess the arrest performance. Although we recognize that a certain level of technical skills is required to perform the arrest simulation test, we interpret our findings to reveal that a higher physical fitness affects the outcome of the arrest situation in a positive manner. For the active duty police officer to be able to master the most frequent excessive physical task of police work the importance of upholding some level of general physical fitness is thereby highlighted as significant. Further, we found a negative correlation between age and both physical fitness and the ability to perform in the arrest handling test. Together our main findings emphasize the need, and the justification, of implementing monitoring of physical fitness in the police profession to ensure the police are capable of performing their job.

## CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

## ACKNOWLEDGEMENTS

Declared none.

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**Study 6 in full text**

Lagestad, Pål; Jenssen, Ole Ragnar N.; **Dillern, Thomas**. *Changes in police officers' physical performance after 16 years of work*. International Journal of Police Science and Management 2014; Volume 16(4) pp. 308-317


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Appendix A: Copyright transfer

Appendix B: Communication with NSD – Norwegian Centre for Research Data

**Norsk samfunnsvitenskapelig datatjeneste AS**
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

Harald Hårfagres gate 29
N-5007 Bergen
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Vår dato: 24.02.2014 Vår ref: 37679 / 3 / LT Deres dato: Deres ref:

## TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 15.02.2014. Meldingen gjelder prosjektet:

| | |
|---|---|
| *37679* | *A study of the effect of different training models, duration, intensity and frequency on repeated sprint ability and agility ability on soccer players* |
| *Behandlingsansvarlig* | *Norges idrettshøgskole, ved institusjonens øverste leder* |
| *Daglig ansvarlig* | *Shaher Shalfawi* |

Personvernombudet har vurdert prosjektet og finner at behandlingen av personopplysninger er meldepliktig i henhold til personopplysningsloven § 31. Behandlingen tilfredsstiller kravene i personopplysningsloven.

Personvernombudets vurdering forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/meldeplikt/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://pvo.nsd.no/prosjekt.

Personvernombudet vil ved prosjektets avslutning, 01.01.2016, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Katrine Utaaker Segadal

Lis Tenold

Kontaktperson: Lis Tenold tlf: 55 58 33 77
Vedlegg: Prosjektvurdering

*Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.*

Appendix C: Communication with REK – Regional Committees for Medical and Health Research Ethics

# Forskningsprosjekt

**Antropometri og fysiologi hos norske kvinnelige elite og ikke-elite fotballspillere.**

Vitenskapelig tittel:
Anthropometric and physiological characteristics and differences in one elite and one non-elite Norwegian female soccer squad

Prosjektbeskrivelse:
Norske kvinnelige fotballspillere har prestert bra internasjonalt de siste 20 årene, men lite systematisk har blitt gjort for å bedre forstå disse prestasjonene. Større undersøkelser bør gjennomføres for å oppnå denne forståelsen. Dette studiet undersøker antropometriske og fysiologiske karakteristikka hos norske kvinnelige elite- og breddefotballspillere. Formålet er å etablere og identifisere standarder for disse, og å klargjøre eventuelle forskjeller mellom disse gruppene. Resultatene av dette studiet vil kunne hjelpe både trenere og spillere til å bedre forstå og utvikle norske kvinnelige fotballspilleres ferdigheter og fysiske kapasitet.
Hovedmålet med studiet er å etablere antropometriske og fysiologiske standarder for elite- og breddespillere. Det andre målet er å kartlegge mulige forskjeller i de målte variablene mellom spillernes posisjoner på banen (målvakt, forsvar, midtbane og angrep).
*(Prosjektleders prosjektbeskrivelse)*

Ref. nr.: 2009/978 Prosjektstart: 17.08.2009 Prosjektslutt: 20.11.2009

Behandlingsstatus: Under behandling
Prosjektleder: jørgen ingebrigtsen

Forskningsansvarlig(e): Høgskolen i Bodø
Initiativtaker: Bidragsforskning

Utvalg: Bare ett kjønn
Forskningsmetode:: Statistiske (kvantitative) analysemetoder

**Behandlet i REK**

| Dato | REK |
|---|---|
| 03.09.2009 | REK nord |

In this PhD-dissertation, Dillern look at his own practice as a natural scientist. For several years he has conducted research within the sports and exercise discipline, published scientific papers and reports and presented research at conferences world-wide. However, at one point, a feeling of not being able to account for choices and decisions made along the way occurred to him. With this came a creeping sense of doubt that perhaps some of the things that he had done in his practice had not been thoroughly thought out. That he, in a manner, had been on some kind of autopilot: as if decisions had been made for him rather than by him. This led to a desire to develop better understanding of his scientific conduct. Hence, starting with questions like what he had done in his practice, how he had done it, and why he had done what he had done, Dillern is drawn into some kind of reflection through his natural scientific conduct. As science largely consists of establishing new knowledge, the primary focus in the text is the process of knowledge development, addressing the deeper and fundamental ontological and epistemological issues concerning the natural scientific practice. Nevertheless, this whole reflective journey of Dillern is now manifested in this doctoral dissertation.

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