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# Technical and psychological key determinants for performance development in biathlon shooting among junior biathletes

Master's thesis in Social Sciences and Sports Sciences. Faculty of Social and Educational Sciences. Department of Sociology and Political Science

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## **Abstract**

**Background:** The purpose of the present study was to identify technical and psychological key determinants for performance development in biathlon shooting in Norwegian junior biathletes, as well as comparing their shooting training to earlier research on the field.

**Methods:** Qualitative in-depth interviews with six biathletes (three male and three female) from the Norwegian Biathlon Federations national team for U23, regarding performance development in biathlon shooting.

**Results:** To manage to identify key determinants, several technical and psychological themes were picked out based on earlier research and themes discussed during the in-depth interviews. The study showed that the technical key determinants highlighted as most important is rifle stability, shooting position, postural balance, triggering and cardiac cycle. Furthermore, the study showed self-efficacy, attention focus and arousal-regulation as psychological key determinants for performance development in biathlon shooting. The study showed no significant sex-differences.

**Conclusion:** The findings of technical key determinants matches with former research. The results emphasize the importance of psychological determinants on performance development in biathlon shooting. The results imply that junior biathletes could benefit from greater knowledge about development of relevant psychological determinants. Nevertheless, the grade of complexity in biathlon shooting makes it hard to conclude, and additional research are necessary to investigate this in a wider matter.

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## 1. Introduction

Over many years, researchers and practitioners have tried to figure out how to in best matters develop elite performance in sports (Vaeyens, Lenoir, Williams & Philippaerts, 2008). With a wide range of sports with different traits, it is hard to find determinants and characteristics of performance development that could apply as general guidance. A broad set of research in the performance development-field within sports over the years, has nevertheless given some recommendations for athletes that want to develop their skills. For example have long-term aims and methods and wide ranging coherent messages and support been found as key features for great performance development (Martindale, Collins & Daubney, 2005).

Biathlon is a sport which combines the skiing in cross country skiing and rifle shooting in the same competition. The sport sets considerable demands to both physiological traits, in addition to fine motor control when shooting in combination with fatigue after high-intensity exercise and under psychological pressure. The physiological demands are relatively similar to the ones athletes meet in cross-country skiing, especially in cross-country skiing competitions performed in skating technique. Earlier research seem to be very limited compared to research in both cross-country skiing and other shooting disciplines (Laaksonen, Finkenzeller, Holmberg & Sattlecker, 2018).

Norway is known as a great winter sport nation, and biathlon has developed to be one of the most popular winter sports in Norway. Their proud traditions in cross-country skiing might had an impact in this. Norway is also one of the most prominent biathlon nations over the last 30 years with athletes like Ole Einar Bjørndalen, Liv Grete Skjelbreid Poiree, Tora Berger og Johannes Thingnes Bøe. The nation has dominated the results in the last World Championships and Olympic Games.

With this as a backdrop, the recent study tries to explore how the Norwegian milieu work with biathlon shooting training, and as well what they characterize as the most important determinants to develop the shooting performance in biathlon. Norwegian junior biathlete's perspectives is working as basis of understanding, through in-depth interviews. The aim of the present study was to identify technical and psychological key determinants of development in Norwegian junior biathletes, by interviewing junior athletes at the Norwegian Biathlon Federations U23-team, as well as comparing their shooting training to earlier research on the field. The overall objective of the study will therefore be as follows: *What are the key technical and psychological determinants for development in biathlon shooting among*

*junior biathletes? Centred on the results can there be found special practical priorities to develop skills within these key determinants?*



## **2. Field of topic**

### **2.1 Development of performance in sports**

The talent development of young and talented athletes into elite performances athletes have been a focus for both researchers and practitioners. According to Martindale et al. (2005) there is a dearth of research to monitor the optimization of this process. Their paper offers an overview of themes found in literature linked to effective talent development in sport. The five key generic features that emerge consistently is: long-term aims and methods, emphasis on appropriate development rather than early selection, individualized and ongoing development, wide ranging coherent messages and support and an integrated, holistic and systematic development (Martindale et al., 2005). The five key generic features are based on the thought that the development process should be seen in a holistic view to identify an effective Talent Development Environment (TDE) (Martindale et al., 2005). Furthermore Martindale et al. (2005) arguments for the importance of quality and correctness of the coaching environment, and that coaches acknowledge that athletes have different needs during different periods of their development, and therefore are in need of different coaching inputs during their development process.

In Güllich (2017) study he examines developmental participation patterns of top international athletes. 83 international medallists and 83 non-medallists were paired together based on age, gender and sport. Through a questionnaire they measured the athlete's volume of organized training in their main sport and other sports during childhood, adolescence and adulthood in addition to participation in non-organized sport activity. Results show that the medallists started at an older age with training in their main sport and marginally accumulated less training in their main sport during childhood and adolescent. The medallists participated in more practise/training in other sports than their main sport before entering their main sport and specialised later than the non-medallists. The results were robust over a wide spectre of sports (Güllich, 2017). These results are substantiated by Güllich (2018) study where elite track and field athletes were compared regarding their developmental sport-specific and non-specific, organised and non-organised (peer-led) sporting activities. The results showed little differences between strong responders and weak responders in total sum of all kinds of sport activities and organised practice. The main difference was that strong responders engaged in more organised practice and competitions in other sports over more years (9 vs 2 years) and specialised in athletics at a later age than weak responders (16 vs 11 years).

According to Phillips, Davids, Renshaw og Portus (2010) research on expert development and talent identification has been too dominated by either environmentalist or genocentric positions. As an example on environment-focused research they use Ericsson, Krampe og Tesch-Römer (1993) who emphasized the role of structured activities with goal-directed skill learning (deliberate practice). Their estimate of 10000 hours/10 years with deliberate practice to reach expert level, is well known in talent development-milieus. As a contrast to this, has other environment-focused studies found that early specialization is not essential for attaining expert sport skills as an adult (Baker, Côté & Deakin, 2005; Baker, Cote & Abernethy, 2003). Other studies have associated the anthropometric, physiological and psychological characteristics you find in elite sports, and found that it is a close relationship between specific Olympic events certain physiological characteristics (Carter, Carter & Heath, 1990; Rankinen et al., 2006). Phillips et al. (2010) and Vaeyens et al. (2008) argues that, despite of lack of evidence and the unstable nature of anthropometric and physical characteristics during adolescent, this type of profiling of physical dispositions has been to leading in talent identification models in sport. On this background Phillips et al. (2010) argues that the former research based on either environment or genes/physiologic as the main traits to explain development of performance in sports, doesn't seem to justify the complexity of the relationship between both environmental and individual limitations. Therefore it is claimed that multi-dimensional models of performance and learning in sports, to understand the complexity in the process of talent and expertise development (Phillips et al., 2010).

Durand-Bush og Salmela (2002) highlights the psychological factors, in addition to environmental factors, to develop to an elite level. They interviewed 10 athletes who had won a gold medal in Olympics and/or World Championships at two separate years. The findings showed that the athletes' personal characteristics related to motivation, self-confidence, perseverance, and creativity. Their training was targeted to develop physical, technical, tactical, and mental elements. In the competitions factors that were highlighted were concerned meticulous planning, evaluations, dealing with pressure, expectations and adversity and focusing on the process rather than the results in the events (Durand-Bush & Salmela, 2002). The authors underline that the athletes did not follow the same path to success, and this suggests that different lanes and several strategies and resources could be taken to develop and maintain expert level in sports.

In McCormick, Meijen og Marcora (2015) also argues for that psychological skill training could benefit for endurance athletes in their review to identify psychological factors that affect endurance performance. They found support for using self-talk, imagery and goal

setting to improve the endurance performance, but it is uncertain if learning more than one psychological skill is better than learning one psychological skill. In addition, the results showed that endurance performance gets weakened by mental fatigue, and that head-to-head competition and verbal encouragement can have a positive effect on endurance performance (McCormick et al., 2015).

## **2.2 Development of performance and training characteristics in biathlon shooting**

This chapter will consist of a brief overview of training and athlete development found and used in different elite environment in biathlon, to give an understanding of some of the demands the informants in this study meets.

In the study from Carlson (2011) the purpose of the study was to explain the fresh success among Swedish biathletes the latest years. The elite national team holding 13 athletes were investigated along with a control group – paired on the background of age, sex and athletic performance. Results showed that elite biathletes were more often born in the early in the year (based on quadruples of a year), a point that is connected to relative age effect (RAE). The elite athletes also had more positive experiences from the years at sport academy than the control-athletes – particularly regarding the coaches ability to individualize training and reciprocity in their communication (Carlson, 2011). An additional finding was that skiing parallel to shooting or biathlon itself at an early age, seemed to could increase the favourable development in senior years (Carlson, 2011).

Sæther, Iversen, Talsnes og Sandbakk (2021) compared high- and low responders to a cross country skiing talent transfer program from the coaches perspective. The coaches in this study revealed that the high responder's greater development both physiological and technical could be assessed to superior motivation and a great ability to deal with adversity in the development process (Sæther et al., 2021).

### ***2.2.1 Perspectives after 2018 Olympics***

In the article from Laaksonen, Jonsson og Holmberg (2018) they sum up the recent advances and perspectives in biathlon after the Olympics in Pyeongchang 2018. Based on reported shooting training from the Swedish national elite team, which picked up four medals in Pyeongchang, it seems that world class biathletes fire over 20000 shots during over 200 training sessions during one season. Approximately 60% of the shots are done in combination with endurance training (9000 (75%) at low, 2000 (15%) at moderate, 1250 (10%) at high

intensity) like skiing, roller skiing or running (Laaksonen, Jonsson, et al., 2018). The fundamentals of this type of combination-training haven't changed much the last decades, but Laaksonen, Jonsson, et al. (2018) underlines that the shooting time and accuracy have improved, thus it is important to reproduce conditions that look like the ones in competition (ex, under time pressure or biathlete against biathlete). The remaining 40% of the shots are fired at rest where the focus often is at improving accuracy (precision shooting) or at the speed of the shooting, including preparation and exit from the range. The focus on getting prepared for the first-shot quickly and getting out of the range as fast as possible has developed to be a central focus for biathletes at top level (Laaksonen, Jonsson, et al., 2018). According to Gros Lambert, Candau, Grappe, Dugue og Rouillon (2003) and Laaksonen, Jonsson, et al. (2018) both shooting at rest and shooting without ammunition (dry-shooting) can develop triggering behaviour, rifle stability and/or holding. In addition, this kind of shooting training can improve relevant mental aspects of shooting (Laaksonen, Ainegren & Lisspers, 2011). Normally athletes do most of the shooting at rest in the early training season (from May), and progress firmly to shooting combined with endurance training (June-November) (Laaksonen, Jonsson, et al., 2018). Another aspect in biathlon shooting is the outdoor conditions, and it is often recommended to train under windy conditions. This is because of the influence of rifle stability, body sway and rifle motion has on the shooting scores, and how these factors distinguishes high- from low-scoring athletes (Gros Lambert, Candau, Hoffman, Bardy & Rouillon, 1999; Ihalainen et al., 2018; Sattlecker, Buchecker, Gressenbauer, Müller & Lindinger, 2017).

### ***2.2.2 Analyse of the most successful male biathlete the last decade***

Schmitt, Bouthiaux og Millet (2020) analysed the training, over an 11-year period, of the most successful male biathlete in the last decade. The participants training progressed from 530 to 700 hours' endurance training, and stood of 86% low intensity training, 3,4% middle intensity training, 4,0% high intensity training and 6,3% strength training. The authors highlight his progressive increase in training volume, especially at low intensity training, as important for his performance improvement.

## **2.3 Technical biathlon shooting determinants**

Biathlon has been an event in the Olympic Games since 1960 (for women from 1992). From 1978 the International Biathlon Union (IBU) standardized the shooting distance to 50m and

the ammunition to 0.22-inch ammunition and smaller rifles, which have been the same standardization until today. In earlier years' biathlon had quite few distances, but nowadays you find four different individual distances and three different relays at the WorldCup-level (IBU). In both the prone and the standing shooting, the range is 50 meters away from the targets. In prone the diameter of the target is 4,5cm, and in the standing the diameter is 11,5cm. A miss in the individual competition gives one minute of penalty time for each shot, unlike all other competitions where each miss gives a 150-m long penalty loop that must be skied before going out on the race course again. In all the three relay-competitions the athletes have three spareshots at every shooting (IBU).

The research on biathlon shooting seems to be very limited compared to other shooting disciplines (Laaksonen, Finkenzeller, et al., 2018). The performance is related to many factors, but mainly to shooting time, the intensive skiing post shooting, weather conditions and the features of the shooting range (M. Hoffman & Street, 1992; Sattlecker, Buchecker, Müller & Lindinger, 2014). As biomechanical factors there have been found results that suggest low vertical rifle motion for prone shooting and low body sway for standing shooting (Sattlecker et al., 2017; Sattlecker et al., 2014). There seem to be less investigations that focus on biathlon shooting under stressful situations and conditions (Laaksonen, Finkenzeller, et al., 2018). In the later years it has become normal to use force platforms to investigate body sway, video analysis of shooting mechanics and laser tracking of the rifle barrel, which give hopes for more findings connected to biathlon shooting in the coming years.

Köykkä, Laaksonen, Ihalainen, Ruotsalainen og Linnamo (2021) investigated the most significant factors determining biathlon prone shooting without physical stress. Shooting performance and several aiming point trajectory variables were measured. They identified four technical components that were directly associated with better shooting performance: stability of hold, aiming accuracy, cleanness of triggering and timing of triggering. In addition, a high pre-shot trigger force level seems to be positive for both the stability of hold and cleanness of triggering. Better stability of hold also was associated with better cleanness of triggering. This shows that both directly and indirectly, stability of hold seems to be an essential quality for successful biathlon shooting (Köykkä et al., 2021).

On the background of these findings I have taken base in three technical main factors for biathlon performance; rifle stability, postural balance and triggering, and in addition psychophysiological features are mentioned in the following section.

### ***2.3.1 Rifle stability***

Many studies have shown that the rifle stability in standing position is crucial for the performance and shooting score in biathlon and other shooting disciplines, and can separate the high-scoring athletes from the low-scoring athletes for both female and male (Baca & Kornfeind, 2012; Mononen, Kontinen, Viitasalo & Era, 2007; Sattlecker et al., 2014; Viitasalo et al., 1999). In Ihalainen et.al (2018) found evidence that vertical stability of the rifle hold to be the one most important factors of shooting performance in both rest and post exercises.

According to Sattlecker et al. (2013) in both air rifle shooting and biathlon the horizontal movement is the major factor that can separate high - from low level athletes. Sattleckers et.al (2013) study pointed at a relationship between displacement of the centre of mass in the anterior/posterior direction and horizontal rifle sway. In another study from Sattlecker et al. (2014) they compared a group of athletes from the World Cup and European Cup to a federal youth squad. The results from the WC/EC-athletes showed lower rifle and body sway (primarily in the cross-shooting direction) in rest, than the federal youth athletes. It has been proven that physical exercise post standing shooting influences negatively at how the rifle is held during standing shooting (M. D. Hoffman, Gilson, Westenburg & Spencer, 1992; Sattlecker et al., 2017). Sattlecker et.al (2017) shows that the movement of the rifle increases as much as up to 50% after a physical load, which shows the correlation between rifle stability and previous physical exercise. Hoffman et.al (1992) found a minimal effect of exercise intensity on the rifle stability in prone shooting, while Sattlecker et al. (2017) found the vertical sway of the barrel to be the main predictor to performance in prone shooting after physical exercise.

Relaxation training and specific holding training has proven it can improve rifle stability and shooting performance (Gros Lambert et al., 2003; Laaksonen et al., 2011). In Laaksonen et.al 's (2011) study the aim was to test the hypothesis that a combined relaxation (applied tension release, ATR) and specific shooting training regimen may enhance shooting ability of biathlon athletes. Seven biathletes of high national level were randomized into an experimental group and were asked to add this special training intervention to their regular training for 10 weeks, while five other biathletes served as controls. The shooting ability of the subjects was assessed before and after the intervention at rest and after roller skiing on a treadmill in a laboratory-based competition simulating assessment. After the intervention period, the experimental group demonstrated a significantly enhanced shooting performance compared to the control group.

### **2.3.2 Postural balance**

Earlier studies on pistol, rifle and biathlon standing shooting has proven that postural balance in the standing stance is a major element to be a successful shooter in standing position. Non-elite athletes show more body sway than the elite athletes (Era, Konttinen, Mehto, Saarela & Lyytinen, 1996; Mononen et al., 2007), and less body sway have a correlation with high-level shooters compared to low-level shooters (Sattlecker et.al, 2014; Sattlecker et.al, 2017; Gros Lambert et.al, 1999). Both Sattlecker et.al (2014) and Era et.al (1996) recommend specific balance training for athletes on a lower level. Previous research in both rifle shooting (Mononen et.al, 2007) and biathlon (Sattlecker et.al, 2014; Sattlecker et.al, 2017; Ihalainen et.al, 2018) shows a relationship between postural balance and the motion of the rifle. That means that a high body sway often gives an unstable rifle, which can give poor shooting performance and results (Mononen et.al, 2007; Sattlecker et.al, 2014).

In standing shooting the standing stance may have an impact on stability. There are a few studies that touch on this subject, but mainly regarding pistol and air rifle shooting. A biathlete has some limitations when taking his stance (skies, poles, thin clothing etc.) compared to a rifle shooter, which often gives them each a distinctive character. Besides, the biathlete has limited time to take his optimal stance compared to a rifle shooter, and therefore the stance may have even greater impact on the shooting performance in biathlon than in rifle shooting. According to Sattlecker et.al (2017) the body - and rifle sway across the line of fire are the best predictor of shooting results, and also is the best factor to divide the experienced shooters from the inexperienced (Era et.al, 1996; Sattlecker et.al, 2014). Furthermore, is the body sway across the line of fire (anteroposterior direction) much bigger than the body sway along the line of fire (mediolateral direction) (Sattlecker et.al, 2014).

In biathlon the comprehensive exercise done before arriving at the shooting range destabilizes the shooting stance (M. D. Hoffman et al., 1992; Niinimaa & McAvoy, 1983). This is also shown in a more general matter, where an increase in breathing rate and heart rate are proven to destabilize our posture (Paillard, 2012). This negative effect that comprehensive exercise load has on the postural balance is a central factor for standing shooting in biathlon (Hoffman et.al, 1992; Niinimaa & McAvoy 1983; Sattlecker et.al, 2013). Also the prone shooting in biathlon is negatively affected by increased heart rate and breathing rate after exercise, but not as hard as in the standing shooting (Evans, Scoville, Ito & Mello, 2003; M. Hoffman & Street, 1992). According to Hoffman et.al (1992) the heart rate drops down to 60-

70% of heart rate-max in standing stance, and in prone shooting even lower because of reactivation of cardiac parasympathetic nerves (Laaksonen et.al, 2018).

### ***2.2.3 Triggering***

The triggering in biathlon demands great fine motor control, and has often been pointed at as one of the most important technical factors in biathlon shooting (Gros Lambert et al., 1999; Kuvås Brevik, 2018). This area seems to be scarce when it comes to systematic and thorough investigations, but there are some findings that emphasize the meaning of triggering. Elite biathlon athletes are shown to have higher trigger forces before shooting than younger athletes (Sattlecker, Müller & Lindinger, 2009). Another finding from Sattlecker, Buchecker, Birklbauer, Müller og Lindinger (2013) is the effect of fatigue on trigger forces, where the effect was strong at the low-scoring biathletes but not for the high-scoring biathletes. It was shown that the timing of the finger movement was negatively affected by the fatigue. Ihalainen et al. (2018) implies that the high-scoring athletes may have advanced a steady triggering performance and a great fine motor - and neural control of the distal joints, even when they experience fatigue.

### ***2.3.4 Shoulder force***

Earlier investigations have shown shoulder force to be a main distinguisher between high - and low scoring performance in biathlon, especially in prone shooting according to Grebot og Burtheret (2007) and Sattlecker et al. (2017). Both those studies show that the shoulder forces decrease after physical activity, and furthermore gives less rifle stability, predominantly in the prone position. An ideal length of the rifle stock gives a significant contact between shoulder and rifle, and can give a more stable hold of the rifle (Grebot & Burtheret, 2007). Sattlecker et. al (2017) found that the horizontal rifle stability gets better when the shoulder and rifle butt sits tight against each other.

## **2.4 Psychological determinants in biathlon**

“Psychological skills training (PST) refers to the systematic and consistent practice of mental or psychological skills for the purpose of enhancing performance, increasing enjoyment, or achieving greater sport and physical activity self-satisfaction”

This is the definition Weinberg og Gould (2019) uses to define PST. In recent years, the research and literature around the development of psychological skills and the importance of



these skills, has become more and more reachable (Ortega & Wang, 2018). It is important to differ between psychological skills, e.g self-efficacy/self-confidence or attentional focus, and psychological techniques which e.g can be imagery and self-talk (Ortega & Wang, 2018). The psychological skills work as the desired outcome, and the psychological techniques as the resources or methods to develop these skills. Ortega og Wang (2018) presents some psychological skills that seem to be proper to enhance athlete's performance in high intensity sports (HIS). Biathlon have many common features with high intensity sports, even it's not defined as such. The results show that self-skills, personal development and life skills, arousal-regulation skills, volitional skills, motivational skills and recovery skills seem to be important to enhance performance in HIS.

This chapter will focus on some psychological skills that seems to be important in biathlon, based on some of the findings from Ortega og Wang (2018).

#### ***2.4.1 Self-efficacy***

Albert Banduras term, self-efficacy, has been widely described in psychology for many years connected to his social-cognitive theory. The term describes the judgement of a person for his ability of executing a specific task (Bandura, Freeman & Lightsey, 1999). Increased self-efficacy seems to be associated with enhanced performance success, and a lack of self-efficacy is linked to decreased performance scores as well as unhealthy behaviour (Ortega & Wang, 2018; Wright, O'Halloran & Stukas, 2016).

Bandura et al. (1999) highlights four main sources to increase the self-efficacy for a human: mastery experience, vicarious experiences, verbal persuasion and physiological and emotional states. Mastery experiences give you information of your earlier successes, and failures. Achieved success often increase self-efficacy, while experience of failure decreases self-efficacy. Vicarious experiences give you information of modelled execution by seeing other performing the skill (Feltz, Short & Sullivan, 2008). This may give increased self-efficacy on the background of model learning and giving a point of reference for social comparison. Verbal persuasion can convince an athlete of his abilities to perform a task, especially if the persuasion comes from a "significant other" (Bandura et al., 1999). Physiological and emotional states give us information about our physiological and affective arousal. Depressions, anxiety or tension are examples of emotions that may affect the self-efficacy negative, while positive emotions may boost your belief in own abilities (Feltz et al., 2008)

Kočergina (2015) investigated Lithuanian biathletes with the aim to identify and evaluate the relationship between the different performance biathletes' athletic preparation model and sports results. One of the objectives was to establish the interaction of expression of female biathletes' mental features (self-efficacy, emotional states, anxiety) and their shooting results during competition. In this study they found a significant correlation between indices of general self-efficacy and the biathletes' perception of their physical abilities during their biathlon shooting event in the competition. These findings implicate a correlation between shooting performance and self-efficacy, and even the perception of their physical abilities during a competition. The last finding is interesting, as it links a negative perception of physical ability during a competition to affect the shooting performance negatively.

#### ***2.4.2 Attention focus and arousal-regulation***

Arousal is often defined as an somatic and cognitive reaction to an stimulus, either an internal or external (Ortega & Wang, 2018). It is commonly claimed that it exists one optimal state of arousal for performing at a high level. This optimal state is depending on a combination of situational factors, individual preferences, cognitive and affective sensations and the requirements from the specific sport (Ortega & Wang, 2018). In the sport biathlon these sport specific requirements are quite special. You need to have control over your arousal during a fatigued physiological state in the shooting range, but out in the skiing tracks you may benefit from having a higher level of arousal to ski at your maximal level.

The state of arousal can often be influenced by the psychological impact of fear and choking under pressure (Ortega & Wang, 2018; Vickers & Williams, 2007). Lindner (2017) investigated the phenomenon "choking under pressure" in Biathlon World Cup competitions. He used data from 11 different seasons of World Cup racing, and found strong evidence for choking under pressure, implying that especially leaders of the competitions are more probable to fail decisive shots. Using more time for the lasts shootings bout led to a decrease in performance (Lindner, 2017). Another interesting founding in the research was the evidence for a momentum effect, where after missing a shot during the last shooting bout, the probability for missing the last shot decreased. This may imply that the fear and pressure decreases, which can make arousal-regulation easier, after missing a shot.

The attention focus is something that may be essential to master the arousal-regulation for an athlete. Luchsinger, Sandbakk, Schubert, Ettema og Baumeister (2016) examined brain activity during shooting. From former research they learnt that higher frontal theta activity was linked to more focused attention and superior performance in goal-directed precision

tasks. The shooting performance in biathlon demands focused attention after high-intensity cross-country skiing. They choose to use biathletes as “experts” and cross country skiers as “novices” in the study. The athletes performed shooting both in a “no physical activity” condition and a “after physical activity” condition. The results showed that the biathletes on average had 6% higher frontal theta activity than the cross country skiers during shooting. It was not found any decrease in frontal theta activity after high-intensity training before the shooting, neither for biathletes or cross country skiers (Luchsinger et al., 2016).

### ***2.4.3 Psychophysiological features of biathlon shooting***

Biathlon is a sport that demands a great set of skills, and the complexity of only the shooting is huge. Elements like the need of fine motor control, time pressure, other competitors, the crowd and the physical load right before the shooting are factors that were described to varying degrees in the last subchapter. The psychological features of rifle and pistol shooting are well represented in research, but the same features in biathlon shooting seems to not have been considered and research in the same degree. Ihalainen et al. (2018) points at cardiac and cortical activity, skin conductance, gaze behaviour and breathing patterns as factors that’s underrepresented in research for biathlon shooting.

In Helin, Sihvonen og Hänninen (1987) study they tried to verify the timing of triggering in relation to the cardiac cycle in shooting. They tested six Finnish rifle and pistol champions and three beginners at shooting. The results showed that the champion shooters triggered during diastole (when the ventricles are being filled and are relaxing) and that the beginners triggered in both diastole and systole, with best results in the diastole. Gallicchio, Finkenzeller, Sattlecker, Lindinger og Hoedlmoser (2019) examined the relation between shooting accuracy and cardiac cycle in biathlon with and without physical exercise. They found that the shots with greatest accuracy was fired away from the phase of the cardiac cycle where the pressure pulse wave occurs after a heartbeat. Physical exercise influences the destabilizing effect of cardiac contraction on shooting accuracy by enlarging it and making it appear earlier in the cardiac cycle (Gallicchio et al., 2019).

To hit a target accurately, one must control the gaze so that the final fixation not only is on the target but also is of sufficient duration to ensure accuracy. A long duration of final fixation or quiet eye is located to be a characteristic of higher levels of both expertise and performance.(Vickers & Williams, 2007).

Vickers og Williams (2007) provided evidence that choking under pressure is associated with changes in visual attention. Ten elite biathlon shooters were tested under separate low-pressure (LP) and high-pressure (HP) conditions after exercising at 55%, 70%, 85% and 100% of their VO<sub>2</sub>max. Managing to direct visual attention externally to critical task information appeared to protect the athletes from choking under HP. The nonchokers maintained their quiet eye longer under high pressure than under low pressure (Vickers & Williams, 2007). The action of giving attention externally to critical task information appears to protect athletes from the normally delimiting effects of hard exercise, anxiety, and pain and allows them to maintain or even increase their level of performance above that found when quiet eye durations are reduced (Vickers & Williams, 2007).

### **3. Method**

In this study a qualitative research method was chosen in turn to create a universal understanding of Norwegian junior biathletes training characteristics and performance development regarding shooting. In sports and especially physical activity we often see quantitative research methods, but this study is structured as a qualitative and explorative integrative case study where we look into the athlete's perspectives (Swedberg, 2020). A case study may help to develop in-depth knowledge about, and a holistic understanding of the unit being studied (Yin, 2009). Case studies can also form the basis for theoretical generalization. The unit studied is then strategically selected as typical of a more comprehensive universe and the results are understood in a larger context (Yin, 2009). Because of the lack of similar studies about the practical performance development in biathlon the design is explorative. The study has an integrative shape in the way that the participating athlete's perception of their shooting training are seen in a relation with common determinants and characteristics of biathlon shooting. A qualitative research method was chosen to gather information from Norwegian biathletes competing in the junior class, and their reflections and perceptions of what's the most important for performance development in biathlon shooting. With the use of concepts like thick descriptions, triangulation and prolonged engagement it is tried to achieve the qualitative credibility and furthermore account for this in the presentation of the results (Korstjens & Moser, 2018).

#### **3.1 Participants**

The participants (3 females, 3 males) in this study were recruited from the Norwegian Biathlon Federation's national junior team. To be included in this study they had to have been a part of the national junior team for the latest competition season. Because all the participants were a part of the national junior team their age were in the gap 20-22 years old (mean: 20.8). All the informants tried biathlon for their first time in their early childhood (mean: 12 years in the sport). All the informants had taken part in a sport school system with a specialization against biathlon in the age of 16 to 19, both public and private schools were represented in the participants. Additionally, several of the informants had won both national and international medals at junior level in the last two seasons. The Norwegian Centre of Research Data (NSD) accepted the research to be after their guidelines. All participants volunteered to this study and signed approval forms before taking part.

<b>Table 1. Overview of the participants in the study.</b>		
	<b>Sex</b>	<b>Years of biathlon experience</b>
Informant 1	M	13-15
Informant 2	M	13-15
Informant 3	M	10-12
Informant 4	F	10-12
Informant 5	F	13-15
Informant 6	F	10-12
Mean ± SD		12,5 ± 0,916

### **3.2 Interview guide**

An interview guide was developed on the background of a review of the topics: performance development in sports, biathlon shooting determinants and performance development in biathlon. In addition to this the guide also included questions that about the participant's background in sports and their introduction into biathlon. This could work as warm-up questions, and to get to know the participant better (Moser & Korstjens, 2018; Roulston, 2010). A few of the questions in the interview guide were open-ended questions, about key topics, such as: 1) What do you see as the most important types of shooting training? 2) How do a typical exercise in shooting look for you? 3) If you look back with today's knowledge, are there anything you would have done different in shooting training in your junior years? The goal with using a semi-structured interview technique, was to make the participants speak freely about the topics from their own perspective (Roulston, 2010). To quality check and test the interview guide, a pilot was completed on another junior biathlete. The experience from this pilot made some impressions about what modifications that should be done in the interview guide. For example, a change in the order of the questions were conducted to connect two questions that could get answers within the same topic. According to Moser og Korstjens (2018) it can be useful to pilot-test the preliminary interview guide to check the relevance and analysis of the content and to pinpoint the necessity of reformulation of questions. Another thing experienced after the pilot testing, was that the interview took longer

time then predicted time (30mins +/-). It was decided that the interviews rather could take longer time, because all the themes and topics during the pilot interview could be interesting findings for the article.

### **3.3 Data collection procedure**

The potential participants were asked by email and telephone if they wanted to participate in the study. The data was collected through semi-structured interviews lasting 45-60 minutes. These interviews were recorded and furthermore transcribed. Before the interview took part, the participants got an explanation about the study and what the interview's theme would be, both through a written information letter and verbally.

Because the participants in the study was in the middle of their competition season, and to make their participation as flexible as possible the interviews were performed using online video conference. Another argument for doing this was the strict regime regarding covid-19-infections the participants lived under, because of up-coming competitions. The interview performed with participant number 6 (P6) was performed approximately one month after the interviews with the other five participants. In contradiction of quantitative research, the qualitative approach gives the opportunity to ask questions that asks "how" and "why" (Roulston, 2010). According to Moser og Korstjens (2018) you should first ask the "what" - and "why"-questions, and then the "how"-questions, to encourage the participants to telling more details. The interview was semi-structured in the meaning that the identical questions in the interview guide was used in a comparable manner. While this gives a certain form of structure of the interviews, the questions were not in the same order in every interview. Dependent of the replies from each of the participants, interesting topics was explored additional by the interviewer with follow-up questions. Questions like "Why do you think that?" and "How do you deal with that?" were used to make sure topics were studied in the depth that is needed.

### **3.4 Data analysis**

All the gathered data was analysed with the thematic analysis described in by Clarke, Braun og Hayfield (2015). It is organized in the following steps: 1. Familiarization: Reading and rereading of the transcripts and making notes. 2. Coding: a systematic process of identifying and labelling relevant features in relation to the research topic. 3. Searching for the themes:

clustering together codes to create a charting of the most important themes in the dataset. 4. Reviewing themes: a pause in the process of creating themes, where you check if the themes is a good “fit” with the dataset and the themes has a distinct “essence”. 5. Defining and naming themes: creating a brief summary of each theme. 6. Writing the report: weaving together the analytic narrative and the data extracts. Analytic conclusions are drawn across themes (Clarke et al., 2015).

The data was read and reread with an open mind to get a sense of the substance, and second the data was coded into relevant features. The codes were established in a deductive way, based on higher-level themes from relevant theory. Furthermore, the codes from the dataset were structured into different groups based on themes. In the fourth step I did a review of already existing themes and developed them further. As I was satisfied with the groups and themes, it continued with naming the themes and giving each theme a short describing. As the final step some suiting and relevant quotes linked to the themes were presented in relation to the earlier research and the aim of the study in the results and discussion (Castleberry & Nolen, 2018). In the coding process it was necessary to take a few breaks from the work to try to return with fresh eyes. This made me for example identify a pattern I had not seen the first times, and I had to go back and make a recoding, and re-structuring of the codes to get the essence out of it (Castleberry & Nolen, 2018).

### **3.5 Ethical considerations**

When I was in contact with the potential participants, they were informed about the objectives of the study. The participants were told both verbally and in paper that it was voluntary to be a part of the study, and that they had the obligation to back out of the study at any time until the publication of the study. The participants were guaranteed confidentiality. Only authorized researchers would get access to the information about the participants and the data collected from the interviews. The participants will at no point be referred to by something else than P1-P6 to ensure that no one could be identified by their citations. As the author of the study I had little or no knowledge to the participants before the study started. Because of my work as a coach in biathlon I had met some of the participants at competitions and training camps at earlier stages. This may have affected the answers from the participants in the interviews. The fact that I have a background as a biathlete and nowadays work as a biathlon coach should also be highlighted. This may have affected my interpretations of the



collected data. In qualitative research, who are often seen as a more subjective because of the researcher are the “instrument” who interpret, it is more common that biases arise.

## **4. Results and discussion**

The aim of this investigation was to describe and examine the training characteristics and performance development among the best junior biathletes in Norway. In the subsequent chapter the findings and results from qualitative interviews with the athletes from the Norwegian Biathlon Federations U23 national team. The findings will be discussed and interpreted in light of previous literature in this field of topic that's reviewed earlier in this study. The thematic analysis revealed some main themes that are the foundation for this chapter – 1) Development of technical biathlon shooting determinants. 2) Development of relevant psychological determinants in biathlon shooting.

### **4.1 Development of technical biathlon shooting determinants**

All of the informants in this study tells about a childhood and adolescent with participation in many different sports activities such as: football, handball, volleyball, cross country skiing, cycling and track and field. As earlier research underlines, top sport performers in adult age often have background of participating in several different activities during their adolescent, combined with a late specialization to their main sport (Baker et al., 2003; Güllich, 2017; Martindale et al., 2005; Phillips et al., 2010). On the other hand Carlson (2011) pointed out that doing skiing parallel to shooting or biathlon itself at an early age, seemed to be favourable for developing specific shooting abilities in senior years. The athletes in this study has a mean of 12,5 years of biathlon experience (Table 2) and their mean age is 20.8 years old, which suggests that the athletes in this study clearly have been doing biathlon shooting at an early age. It's appropriate to underline that the athletes in this study hasn't performed at world class senior level yet, but as a part of the National U23-team the Norwegian Biathlon Federation most certain want to see some of them doing it in the future.

Based on earlier research there are a few individual technical biathlon shooting characteristics that are proven to be key factors for successful performance (Laaksonen, Finkenzeller, et al., 2018). The results from the interviews also showed that some of these factors seem to be something the athletes are working deliberately to develop throughout their shooting training. There seem to be a difference in what the athletes emphasize as the most important technical shooting characteristics for themselves, which may be explained by their different strengths and weaknesses as athletes:

*II: "I would point out the rifle stability and the breathing as the most important determinants for me."*

*I4: “Purely technical I would say the abilities in breathing and triggering are the most important determinants.”*

The athletes did not completely agree about what is *the* most important technical determinant, but all of their answers could be gathered into three main themes: rifle stability, shooting position, triggering and cardiac cycle. This seems to fit well with what Laaksonen, Finkenzeller, et al. (2018) found in their review and in the earlier research presented in the recent study (Gallicchio et al., 2019; M. D. Hoffman et al., 1992; Ihalainen et al., 2018; Köykkä et al., 2021; Sattlecker et al., 2017).

#### **4.1.1 Rifle stability**

Every one of the athletes mention rifle stability (in Norwegian they use the term “holdeområde”) in their interviews, and almost everyone points it out to be one of the main factors for performance in standing shooting. There seem to be a consensus about that rifle stability is something they are prioritizing in their training:

*I2: “If we are talking about standing shooting exclusively is holding training my most important training form. It works like the solution for me, to find back to the “sweet spot”, then it is only holding training that works. It works all the time, nearly [...] the holding training narrows down the aiming area.”*

Nevertheless, some of the athletes mentions that this is something they have taken the consequences of the last couple of years. A couple of the athletes even mention that they from early junior years have been told that holding training for working with the stability of hold is important training, but still hasn't done much of it:

*I3: “If I could change something in my junior training I would've done more holding training to improve my rifle stability. I thought it would be enough to shoot combination training and shooting without physical load, but to have time in the standing position was something I did too little of.”*

*I5: “We had lectures with people that told us dry firing and holding training was important and that Vetle Sjaastad Christiansen dry fired five hours a week. But we thought that dry firing was boring. [...] I think you need to get a revelation about it yourself. As an adolescent it often doesn't help if adults tell you what to do, you have to experience it on your own.”*

The stability of the rifle have proven to be an important determinant of performance in both biathlon and numerous other shooting disciplines (Baca & Kornfeind, 2012; Laaksonen, Finkenzeller, et al., 2018; Mononen et al., 2007), and can separate high – from low-scoring (high- and low-performing) athletes according to Sattlecker et al. (2017). As mentioned, most of the athletes did experience rifle stability as one of the main factors for performance in standing shooting, but it is a quite big difference in how much time they use in trying to develop this ability. Holding training and using time in their shooting position is mentioned as main training methods to develop their rifle stability:

*I3: “The movement of the aiming point (“holdeområdet”) is quite easy. It’s all about standing in the shooting position and aim at the target. That is what’s worked out for me, and I know it has worked for others to.”*

Earlier research has also shown that specific holding and relaxation training can improve rifle stability (Gros Lambert et al., 2003; Laaksonen et al., 2011). In the athletes’ reported shooting training (Table 1) in their last full season we find a correlation (corr = 0.58) between the time used at dry firing (where a severe amount is holding training) and hit percentage in competitions the same season. It is important to point out that you have to be careful to generalize from sample of six athletes which are very small. Based on these sayings from athletes and results from earlier research it may seem that an even bigger focus on rifle stability and holding training is something that practioners and coaches should facilitate. Furthermore, it could be recommended to do special biathlon specific balance and other rifle stability training forms used in basic shooting.

Due to the recomandation of a bigger focus on rifle stability and holding training, it was interesting to take a look into the numbers of performed shooting training by the informants in this study. The numbers in Table 2 are gathered from their training diaries from the season 2020-2021. The numbers are divided into characteristics based on the Norwegian training diary from Olympiatoppen (OLT). OLT is an organisation that is a part of The Norwegian Olympic and Paralympic Committee with responsibility for training Norwegian elite sport.

**Table 2. The athletes performed shooting training in the 2020-2021 season (mean  $\pm$  SD), distributed at total shooting time (hours), time dry firing (hours) and total amount of shots fired (shots). Hit percentage (%) in competitions during 2020-2021 season.**

	Mean $\pm$ SD
Total shooting time (hours)	105.5 $\pm$ 31.6
Dry firing (hours)	27.8 $\pm$ 9.2
Shots fired (shots)	11780 $\pm$ 4134
Hit percentage (%)	82.9 $\pm$ 5.9

If you compare the performed shooting training of the informants in this study, with the numbers Laaksonen, Jonsson, et al. (2018) found that the Swedish biathletes who won medals at the Olympic Games in Pyeongchang 2018, you find some clear differences. The Swedish athletes fired in average approximately 22000 shots in the season, which is nearly twice as much compared to the informants in this study. They also carried out 120-130 sessions dry firing, which is not so easy to compare with the numbers from the informants which is measured in hours of dry firing. The impression after the interviews is that a typical dry firing session often is about 30 minutes for some of the informants:

*I4: "A dry firing session is rarely above 30-40 minutes for me, because I feel I need to be very focused when I do dry firing. After 30-40 minutes I'm quited cooked mentally."*

If 30 minutes is a normal length of a dry firing session, it means that 27.8 hours can be converted to 55-60 sessions of dry firing. That's under half of the number dry firing sessions that the Swedish athletes performed in a season leading up to the Olympic Games in Pyeongchang. It is important to mention that the athletes in this study is junior elite athletes and the athletes in the Laaksonen, Jonsson, et al. (2018) study is senior elite athletes. Nevertheless, it may seem that the amount of shooting training doesn't have to be as gradually built up as physical training considering overtraining and overload.

#### ***4.1.2 Shooting position and postural balance***

The shooting position and the postural balance is something that is closely related to the rifle stability in the standing shooting. Several studies in both biathlon and rifle shooters have implicated that less body sway are shown in elite athletes compared to other athletes (Era et al., 1996; Mononen et al., 2007; Sattlecker et al., 2009). It is also natural to assume that more body sway gives more motion in the rifle, and in that way has a relationship to the rifle stability. This is something that earlier investigation also has proven (Ihalainen et al., 2018; Sattlecker et al., 2014).

It seems that some shooting stances might improve the stability. In the study on pistol shooters from Hawkins (2013) showed that an angle of 15 degrees to the line of fire gave the best overall performance for air pistol shooters. In biathlon this doesn't need to be transferable because of the different hold on the rifle, combined with the rifles weight that may demand a different approach. Another big difference is the limited time biathletes have to get in to the ideal stance compared to pistol/rifle shooters. Because of this you may argue that the stance is even more important in biathlon, and the ability to get into the exact same stance every time is even more demanding than in rifle/pistol shooting.

Some of the athletes highlight the importance of having a shooting position and stance as kind of a framework for the rest of their shooting performance:

*I2: "A good shooting position in both the prone and standing is extremely important. If you don't have a solid position it would affect everything else. If you have a solid shooting position it gives you good assumptions for shooting well."*

Two of the athletes describes the shooting position and stance in this way: if the framework is bad it makes it harder to execute the rest of the shooting process. One of the athletes emphasise a tight hold of the butt plate of the rifle and the shoulder as an important factor for better rifle stability:

*I5: "For me, a tight and rigid position is dependent of a tight contact between the shoulder and the butt plate, especially in the prone position. The ideal length of the rifle is important to enhance this. This is even more important when we are physical exhausted arriving the shooting range."*

### ***4.1.3 Triggering and cardiac cycle***

The ability to make a stable and firm triggering is pointed out to be a main factor in many shooting disciplines. When it comes to the triggering and cardiac cycle, all of the informants highlights these as important factors for their shooting performance. Several of the informants point out the importance of triggering for their performance in the shooting range:

*I6: "I work through my whole plan for the technical execution of shooting before starting. Then I mainly think of the breathing, the triggering and the freezing of the aim point."*

*I5: "Purely technical I see breathing and triggering as the most important to control the shooting."*

These evaluations from the informants seem to correspond with earlier research, which underlines the importance of the ability to have a steady triggering performance and great fine motor – and neutral control of the distal joints even under high fatigue (Ihalainen et al., 2018; Sattlecker et al., 2013).

A point that a few informant's mentions is the ability to make a steady "freeze" of the movement in the target. In the prone position this is nearly connected with the cardiac cycle and the breathing. When a biathlete fills its lungs with air in the prone position the aiming point will move downwards, and when the athlete breaths air out of the lungs the aiming point often will move upwards. This makes a ground for different interpretations of when it's the best time to fire the shot during the cardiac cycle. There is most certain many different ways that this is done, also in high-level athletes, both with a freeze moment and without it. In the Norwegian milieu it is most usual to freeze the aim point at the target after breathing air out, and then deliver the shot (Kuvås Brevik, 2018), and thus using the outbreath to move into the target from below. The amount of air that are breathed out is individual, and one of the informants point this out:

*I6: The freeze is the most important for me in prone position. And actually getting a fully freeze and not a slow movement. And the difficult thing is to do exactly the same every time you perform a shot. Just as much air out, the same velocity of the movement into the target, and the same deceleration of the movement before the freeze."*

The results from the interviews clearly show that to perform an exactly like “freeze” every time is important to get a good rhythm in the shooting. Gallicchio et al. (2019) pointed out that the shots with greatest accuracy was fired away from the phase of the cardiac cycle where the pressure pulse wave occurs after a heartbeat, which gives the shooter a short window to deliver the shot after the freeze in prone position. The fatigue from physical exercise makes this window even smaller as the cardiac contraction is enlarged. Therefore, it seems to be important to practice on who to best solve the cardiac cycle, timing of freeze and delivering of the shot. As several athletes underlines it is important to manage to do this in the exact same way every time.

## **4.2 Development of relevant psychological determinants in biathlon**

Every one of the informants underlines the influence of psychological skills on the performance of their shooting performance in biathlon. Two of the athlete’s point at the psychological skills as the most important factor immediately after being asked what’s the most central factors:

*I3: “The psychological skills are what I think I would say is the most important to manage the shooting. Of course is it important with a relaxed shooting position and rifle stability, but for me the psychological skills are what I think is the most important.”*

*I4: “I look at the sure of oneself and the self-efficacy as the most important determinants.”*

It seems like it is several psychological aspects that are important for the athletes. Based on the answers it is two main psychological themes that are highlighted: self-efficacy and attention focus/arousal regulation. These to themes are brought to the table from several of the informants, and all of the informants are discussing at least one of these terms in their interviews.

### **4.2.1 Self-efficacy**

Self-efficacy and confidence is terms that every one of the informant’s points at, as a central factor for the shooting performance, if not the single most important factor for performance



and development within shooting. Three different athletes point this out in the following quotes:

*I3: “Have a strong belief in the things you do. If you don’t believe the things you do are the right thing to do, I think it’s difficult to get quality. To have the belief is important to me. I do very little of the things I don’t believe will make me better, both in shooting and physical training.”*

*I5: “Everyone (at this level) knows how to shoot. When you are at a certain level it can be difficult to point out why it’s working or on the other side, not working. I think this is based on self-efficacy and the believe in your own abilities.”*

*I2: “[..] The psychological is so important in the competitions. If you are just a bit unsure on your performance, you might easy shoot two misses.”*

These quotes all highlights the importance of a strong self-efficacy related to the task they need to perform in a competition. Research from wide fields underbuilds the importance of self-efficacy and confidence to perform at your top level, both in biathlon and other sports (Feltz et al., 2008; Kočergina, 2015; Ortega & Wang, 2018). The informants point out several different things that builds a strong self-efficacy regarding the shooting performance. One athlete point out that he needs to feel that he’s shooting position are at 100% to perform at he’s best:

*I2: “After a lot of time in my standing shooting position I often feel confident and have high believes in my performance.”*

All informants say that the confirmation of having the different technical factors in place, give them an increased self-efficacy. Some informants explain that specific training forms, especially shooting combined with high intensity training, are needed to maintain or increase their self-efficacy in the final phase before competitions:

*I6: “If my coach told me that I wasn’t allowed to perform shooting combined with HIT, I would get a feeling of insecurity. It’s so important to me because of the specificity, and coping this type of training works as boost of my self-efficacy and confidence.”*

*I3: “To get many repetitions and implementations at what I’m supposed to do in a competition, is important to me. The specificity is an important part of my shooting philosophy.”*

The point of former mastering experiences of a task is one of Bandura's four main sources to influence the self-efficacy. Bandura et al. (1999) means that this is the most influential source of efficacy information as they give the most authentic evidence of whether a person can master what the task demands for success. Failure often damage the self-efficacy, in the same way as success often builds a strong belief in one's efficacy. In a biathlon specific matter, it may seem like shooting in combination with high intensity training is the training form that increase the informant's self-efficacy to the greatest extent. As the athletes highlight, it seems to be linked to the fact that shooting in combination with high intensity are the training form that is most similar to the conditions they face in competitions. Athletes may meet situations where sickness or injuries make it difficult to perform shooting in combination with high intensity training, even in competition season. Then it may influence the self-efficacy in a positive way to find other training forms that meets the needs of mastering shooting in specific competition situation. Several athletes describe the fatigue, unbalance and high movement of the aiming point trajectory as things that characterize the shooting situation in competitions. If coaches and athletes manage to design sessions where fatigue, unbalance and high movement of the aiming point trajectory it may function as a replacement for shooting combined with high intensity training.

#### ***4.2.2 Attention focus and arousal-regulation***

The ability to control its own attention is recognized as a central factor for performance in several different sport disciplines. In research in the field of psychological skills training these basic mental techniques are largely used: imagery, self-talk, goal-setting and physical relaxation techniques. These techniques can be widely used to develop different psychological skills. In this section I'm going to focus on the psychological skills of attention focus and arousal-regulation. Attention focus is something that came up as a theme in several of the interviews with the informants, and together with arousal-regulation it is applicable, in sports in general and biathlon specifically, according to earlier research (Lindner, 2017; Luchsinger et al., 2016; Ortega & Wang, 2018; Vickers & Williams, 2007).

Biathletes need to have a capacity to focus on shooting under high pressure, with stimuli that may disturb and be interfering. Examples can be the sounds from spectators,

visual attention of competitors or just thoughts about the demands to achieve success. Strategies to cope with this, and to enhance one's attention focus can be crucial. One of the informants tells about his experiences in this way:

*I3: "I think it can be important to tell someone, or just yourself, about your plan for the competition or session. I use to have a chat with my coach before competitions, where I tell about my well-defined plan. I have experience from pressed situations in competitions where my attention floats away and I'm not able to switch back to my tasks. But when I talk about it out loud in advance I feel a stronger control and it's easier to switch back to the tasks I told my coach about."*

This is a very interesting point, which may be connected to the psychological technique self-talk. He feels its positive for his attention to do self-talk in advance of a competition or session, but even more positive to tell things out loud to other persons. The commitment that follows with telling your plan to others may function as a way of goalsetting, which is a well-known basic mental technique.

Two of the informants point out the connection between having few tasks to work with at the same time, and the ability to enhance their attention focus to the tasks:

*I1: "The fact that I am so confident in the one or two tasks I have prepared, make me feel I have more capacity to have a sharp attention."*

*I3: "If I have to many tasks I have experienced that my focus float away, I get eager and do things too fast. When I leave the range I ask myself "What happened there?" It's just flashing by."*

*I6: "I use to have only one task, and do that task 100% before."*

They describe the competition situations as stressful and the point of having just one simple task to focus on, makes things easier for them than having several tasks to keep their mind on. The fact that this may be an important factor for attention focus, makes this theme something that can be interesting to do some further investigation into.

Informants point at a complex relationship between self-efficacy, anxiety-traits, arousal and tension. Long periods without the feeling of mastering central shooting skills have given informants mild anxiety symptoms in some situations:

*I5: "I have experienced to get kind of a phobic anxiety for coming into the shooting range during competitions. After many bad experiences (with shooting) over a long period of time, I felt an anxiety and increase in physiological arousal and tension coming into the shooting range."*

*I4: "My experience is that low self-esteem and self-efficacy makes it easier to choke under pressure [...] In periods with lower self-efficacy it is harder to control physiological tension and arousal, and I feel less psychological pressure can make me choke."*

The informants points at several bad experiences in the last competition period, that gave the athlete anxiety traits and an increase in physiological arousal and tension that made the shooting situation even harder to master. This aligns with the findings in earlier research, where uncontrolled increase in arousal and tension seems to be connected to weaker performance (Birrner & Morgan, 2010; Gros Lambert et al., 2003; Laaksonen et al., 2011). The connection between choking and self-efficacy is also quite interesting. Vickers og Williams (2007) points out evidence of choking under psychological pressure in biathlon, and it is interesting that an athlete say that choking can be related to their self-efficacy.

Due to the informants underlining of the importance of psychological skills, and specially the ability to focus your attention, it was interesting to investigate how this affect their training characteristics. The informants where asked what they do to develop their psychological skills and performance. Informant number 5 says this:

*I5: "I think it is important to prioritize psychological training, but it is so abstract that it makes it difficult to know what it is and what it implies. I don't have a structural training plan for developing psychological skills, but I think it is important to train your head."*

The informant describes developing of psychological skills abstract and difficult to imply into the training program. Furthermore, the informant says that they have learned a wide range of sessions and structures to build a training plan to develop physical and shooting performance, but they have little knowledge of how to develop psychological skills. Quite the same perception is described of another informant:

*I2: "We do some shooting specific psychological training with duels, relays and exercises were you get to feel the pressure and have to focus on your attention. The*

*coach may try to get into our heads by commentating the shooting underway. But I rarely have any purely psychological training with the aim of developing skills.”*

These answers may shed a light at the fact that athletes miss knowledge and a clear framework for structuring an appropriate training schedule for developing psychological skills. Simultaneous it is no doubt that the informants underline the importance of developing psychological skills of attention focus and tension regulation, compared with how strong they emphasize the same determinants for biathlon shooting performance.

### **4.3 Overall discussion**

On the basis of interviewing, and furthermore discussing, shooting performance and shooting training with athletes of the Norwegian Biathlon Federations U23-team this study has tried to identify key determinants of biathlon shooting performance in light of well-known performance development approaches. It has been used earlier research on this field as a foundation of understanding, to discuss the results and findings from this study (Baker et al., 2005; Durand-Bush & Salmela, 2002; Laaksonen, Finkenzeller, et al., 2018; Martindale et al., 2005).

When the informants were asked to summarize what they mean are the two most important determinants for shooting performance the answers contained some differences, but they all highlighted psychological factors as one of the two most important determinants for their own performance. Informant 2 highlights attention focus:

*I2: “As I mentioned earlier: the shooting position and the psychological factors are the most important. Especially the ability maintain attention at your task.”*

Other psychological determinants are also highlighted. Self-efficacy and the belief in own abilities are determinants three of the informants points out as essential:

*I1: “For me the most important is to do things as simple as possible. When I find adjustments and tasks that work for me, I don’t want to complicate it. In shooting I think that’s the key for me, it gives me a stronger belief in myself and my abilities.”*

*I4: “I look at confidence in your own abilities as the most important determinant for me.”*

*I5: “In addition to gaze behaviour, the determination when I carry out my shooting is very important for me. Make sure you are determined and do not hesitate. When I speak about it now, it gets clear for me that its basically psychological abilities and a self-efficacy.”*

Considering the psychological determinants for biathlon shooting performance, the athletes were clear about three specific themes: self-efficacy, attention focus and arousal regulation. The results from the interviews specially underlines the significant importance of having a strong belief in your own abilities. These findings supports earlier research, which have pointed at the importance of self-efficacy and well-being for performance development in general, and in sports (Bandura et al., 1999; Feltz et al., 2008; Wright et al., 2016). The connection between self-efficacy and biathlon is something that seems to be narrowly investigated in earlier research, and may be a field that is interesting for further research.

When it comes to technical determinants the answers differ a bit more, but rifle stability, postural balance and triggering/cardiac cycle is all pointed out as important:

*I2: “A shooting position that gives good balance in combination with triggering is the most important determinant for me.”*

*I3: “For me it is all about the “holdeområde” and the rifle stability both in prone and standing shooting.”*

*I5: “Of the technical determinants, for me the gaze behaviour is the most important.”*

Regarding technical determinants, the results was divided into three main themes: 1) rifle stability, 2) shooting position and postural balance, 3) triggering and cardiac cycle. Every one of these determinants was emphasized by several of the athletes. These results seem to support the existing literature on biathlon shooting, where the same determinants have been proven to be decisive for biathlon shooting performance (Gallicchio et al., 2019; Laaksonen, Finkenzeller, et al., 2018; Sattlecker, Buchecker, Gressenbauer, Müller & Lindinger, 2016; Sattlecker et al., 2017; Sattlecker et al., 2009).

The psychological and technical determinants highlighted in the recent study, seems to have a clear connection. The informants emphasize the importance of mastering experiences of shooting and furthermore mastering experiences of technical determinants. For example, the experience of having a solid shooting position with a feeling of control over postural balance and the rifle stability, is highlighted as sources to a stronger self-efficacy. In the same way does experiences with managing to do things in the exact same way over time, regarding

triggering and gaze behaviour, according to the informants. These examples match the number one source to a stronger self-efficacy according to Bandura et al. (1999), which is former mastery experience.

Informants mention the impact of focus attention on carrying out technical skills. In periods they are struggling with their shooting performance, some informants perceive that the demands are greater for focused attention. In periods where they are in a “flow-state” and their execution of technical tasks goes automatic, the demands for focused attention are less for performing well. These findings show us that psychological determinants as self-efficacy are affected by the execution and level of the technical determinants, but also that the technical determinants are being affected by the performance level of the psychological determinants. Informants emphasize that this mutual dependence can be vulnerable because bad experiences regarding both technical and psychological determinants, may make a “vicious circle-effect” it could be hard to get out of. Low level-performing of technical tasks over a long period combined with bad results, can give lower self-efficacy, and lower self-efficacy may affect the technical performance to an even lower level. Several of the informants underline the importance and effect of going back to simple tasks and simple shooting sessions with high probability to achieve a mastering experience, to get out of the “vicious circle”. This may be a practical priority to look into for coaches and athletes who experience to struggle with shooting performance over longer periods. This mutual dependence and vicious circle-effect could be interesting to look at in further research.

The results in the recent study showed that several informants describe little knowledge and a clear framework for structuring an appropriate training schedule for developing psychological skills. Simultaneously it can seem like informants underline the importance of developing psychological skills of attention focus and tension regulation, compared with the importance they emphasize these determinants for biathlon shooting performance. This may suggest that an increased focus on developing psychological skills for younger biathletes in Norway could be suitable. On the other side it is important to mention that this study is investigating only six informants, and therefore the results may not be representative for the whole group of junior/adolescent biathletes in Norway. Nevertheless, it could seem like more emphasis in biathlon shooting research should be placed on the athletes’ perspectives and perceptions of psychological skill development.

Because this study has both female and male athletes, it was interesting to examine if it would be some sex-differences. The results showed small to no differences in the answers about determinants for biathlon shooting. Both females and males told about the same

technical and psychological determinants, which indicate small to no differences. It's difficult to find much sex-based research about biathlon shooting, and the recent study doesn't imply significant differences either. Because it is few studies about females in biathlon, it could be interesting going deeper into the sex-differences during this field. One of the most interesting findings in the recent study indicate some sex-differences, and this was the differences in shooting training done previous season. Mean numbers of shooting training previous season: fired shoots men (M): 14095 vs female (F): 9465, shooting training 126h (M) vs 85h (F) and dry firing 35h (M) vs 20h (F). The hit percentage the following season was 86,4 (M) vs 79,3 (F), which may imply a connection between performance and training amount. It is important to mention that one should be cautious to generalize on basis of results from a limited selection like this study has, both regarding hit-percentage and sex-differences. Nevertheless, compared to the numbers Laaksonen, Jonsson, et al. (2018) reported that Swedish elite senior athletes shot, you may imply that some of the Norwegian juniors could benefit from doing more shooting training, both in shoots and amount of time from a performance development perspective.



## **5. Strengths and limitations**

In this study a group of six informants have shared their experiences and perceptions through in-depth interviews. A group of six informants is a limited selection, and makes it difficult to generalize features to use for other groups and athletes. Seen in retrospect, it would be great to interview more athletes combined with interviewing coaches of the same athletes. The results from this study, can in best work as careful advices for athletes and groups with similar characteristics. This study builds on qualitative data, and just a few quantitative data (hit percentage), and it could have been interesting to just a more mixed methods approach to get a more holistic approach to the talent development process, like both Martindale et al. (2005) and Phillips et al. (2010) suggests. A strength of the study is the fact that both genders are represented equal in the informants. The results implied none to small differences between the genders. Furthermore, it seems like this study is in a field with modest amount of earlier research, especially with qualitative research from the athlete's perspective. Therefore, it may be interesting doing more research about psychological determinants in biathlon from the athlete's perspective.

## **6. Conclusion**

By using in-depth interviews on six junior athletes at the Norwegian Biathlon Federations U23-team, the present study has investigated what are the technical and psychological key determinants for development in biathlon shooting among junior biathletes. The results highlights rifle stability, shooting position, postural balance, triggering and cardiac cycle as the technical key determinants for developing performance in biathlon among juniors. Self-efficacy, attention focus and arousal-regulation are revealed as psychological key determinants for developing performance. The study showed none significant sex-differences. The findings also imply that Norwegian junior athletes may have a scarce knowledge about developing the psychological skills that are emphasized as important for biathlon shooting performance. Compared to former research it may be suggested that the athletes in this study can benefit from doing a bigger amount of shooting training. Nevertheless, the grade of complexity in biathlon shooting makes it hard to conclude, and additional research are necessary to investigate this in a wider matter.

## **Acknowledgments**

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## Attachments

### *Attachment 1: Interview guide*

#### **Intervjuguide – intervju av utøvere på NSSFs U23 lag**

##### **Innledning**

- *Bakgrunn:* I hvilken alder startet du med skiskyting? Drev du da med andre idretter samtidig? Driver du med flere idretter i dag? Hvis ikke, hvilken alder spesialiserte du deg mot kun skiskyting?

##### **Generelt skytetrening**

- Hvordan fordeler din skytetrening seg når det gjelder tørrtrening, basisskyting, rolig kombinasjon og hard kombinasjon? (antall timer)
- Hva anser du som de viktigste faktorene og ferdighetene for å beherske skytingen i skiskyting?  
Oppfølging: pust/sikting, holdeområde L+S, balanse i ståendestilling, avtrekk, mentale ferdigheter, skytestilling L+S
- Hva slags skytetrening mener du man må prioritere for å utvikle disse ferdighetene?
- Hvilken av de fire hovedkategoriene skytetrening anser du som den eller de viktigste for deg der du er i dag? Oppfølging: har dette endret seg ilt juniortiden?

##### **Utvikling**

- Hva har vært den viktigste typen trening for å utvikle skyteferdighetene dine gjennom junioralder? Oppfølging: har dette endret seg gjennom junioralder?
- Har du eksempler på hvordan ville du lagt opp en skyteøkt (innhold, gjennomføring, hjelp av andre etc) for å best mulig utvikle de sentrale skyteferdighetene?
- Sett i ettertid, er det noe du angrep på at du ikke prioriterte mer/mindre av i skytetreningen som junior?
- Du driver med en komplisert idrett som har to hovedkomponenter i form av langrenn og skyting. Hva anser du som din styrke som skiskytter?
- Hva anser du som viktigst av disse to komponentene? Hvorfor? Har du endret oppfatning rundt dette mens du har vært utøver?

##### **Laserskyting**



- I hvor stor grad mener du bevegelsessensorert laserskyting er et nyttig verktøy i treningsarbeidet? Hvorfor?
- Hva synes du er det beste av innendørs, tørr lasertrening og utendørs, skarp lasertrening? Hvorfor?
- Hvordan synes du bruk av laserverktøy bør organiseres for best læringsutbytte? *Om en effekt for trener/utøver-relasjonen blir nevnt, gå i dybden uten ledende spørsmål.*

### **Trener/utøver-relasjon**

- Hvordan foretrekker du å få hjelp av trener under en skyteøkt? Hvorfor?
- Hvordan balanserer din(e) trener(e) trening i henholdsvis langrenn og skyting? Føler du dette fungerer på en god måte?

### **Treningsmiljø?**

- Hva ville du, rent hypotetisk, foretrukket: oppfølging av trener under to-tre fellesøkter sammen med flere utøvere eller individuell oppfølging av trener under en økt? Hvorfor?
- Hvordan kan en trener best organisere skytetrening for en gruppe på 6-10 stk? Endrer dette seg om gruppen består av 20 utøvere?

### **Oppsummering**

- Hva mener du er de viktigste treningsprinsippene for å utvikle skyteferdigheter?
- Og hva er de viktigste delene av din skytetrening?

## Attachment 2: Confirmation from NSD

23.08.2022, 01:02

Meldeskjema for behandling av personopplysninger

[Meldeskjema](#) / [Hva kjennetegner skytetreningen og ferdighetsnivået til de beste ju...](#) / Vurdering

### Vurdering

**Dato** 17.02.2022  
**Type** Standard

**Referansenummer**  
802411

**Prosjekttittel**  
Hva kjennetegner skytetreningen og ferdighetsnivået til de beste junior-skiskytterne i Norge

**Behandlingsansvarlig institusjon**  
Norges teknisk-naturvitenskapelige universitet / Fakultet for samfunns- og utdanningsvitenskap (SU) / Institutt for sosiologi og statsvitenskap

**Prosjektansvarlig**  
Stig Arve Sæther

**Student**  
Andreas Kvam

**Prosjektperiode**  
18.01.2022 - 31.05.2022

[Meldeskjema](#)

#### Kommentar

Det er vår vurdering at behandlingen vil være i samsvar med personvernlovgivningen, så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet den med vedlegg, samt i meldingsdialogen mellom innmelder og Personverntjenester. Behandlingen kan starte.

#### TYPE OPPLYSNINGER OG VARIGHET

Prosjektet vil behandle alminnelige personopplysninger og særlige kategorier av personopplysninger om helse frem til 31.05.2022.

#### LOVLIG GRUNNLAG

Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 nr. 11 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse, som kan dokumenteres, og som den registrerte kan trekke tilbake.

For alminnelige personopplysninger vil lovlig grunnlag for behandlingen være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 a.

For særlige kategorier av personopplysninger vil lovlig grunnlag for behandlingen være den registrertes uttrykkelige samtykke, jf. personvernforordningen art. 9 nr. 2 bokstav a, jf. personopplysningsloven § 10, jf. § 9 (2).

#### PERSONVERNPRINSIPPER

Personverntjenester vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen:

- om lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lenger enn nødvendig for å oppfylle formålet.

#### DE REGISTRERTES RETTIGHETER

Vi vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: innsyn (art. 15), retting (art. 16), sletting (art.

<https://meldeskjema.nsd.no/vurdering/6177f231-5943-4be2-a8b1-32e10d3a7858/0>

1/2

## **Vil du delta i masterprosjektet ”Investigate what athletes and coaches consider best practise to develop shooting performance among Norwegian junior – and young senior biathletes”**

### **Bakgrunn og formål**

Jeg er masterstudent ved Norges Teknisk Vitenskapelige Universitet (NTNU) i Trondheim, og holder for tiden på med en masteroppgave som handler om skytetrening blant skiskyttere. Jeg ønsker i den forbindelse å samle ulike data fra skiskyttere på høyt internasjonalt/nasjonalt nivå.

Masteroppgavens tema/forskningsspørsmål er: ”Hva kjennetegner skytetreningen og ferdighetsnivået til de beste juniorskisytterne i Norge?”

Formålet med oppgaven er derfor å utvide kunnskapen knyttet til hva slags skytetrening som gjennomføres blant norske skiskyttere og hvordan den påvirker ferdighetsutviklingen til utøverne. Denne kunnskapen vil kunne være til nytte for trenere og utøvere for hva slags skyteferdigheter og skytetrening som bør prioriteres.

Vi spør deg om å være med, fordi du er en skiskytter på nasjonalt/internasjonalt nivå. Hvis du har lyst å være med i forskningsprosjektet, må du skrive under på siste ark i dette brevet, og da vil vi ta kontakt med deg.

### **Hva innebærer det for deg å delta i studien?**

Ønskelig datainnsamling til oppgaven er gjennomføring av intervju av deg som deltaker, og i tillegg deling av resultater fra lasertester og data fra treningsdagbok. Hvis du velger å delta i prosjektet innebærer det gjennomføring av et videointervju og deling av slik data. Intervjuet vil kun inneholde spørsmål knyttet til forskningstema. Intervjuet vil ta 30-45 min og jeg vil gjøre lydopptak av intervjuet.

### **Det er frivillig å delta**

Det er frivillig å delta i prosjektet. Det betyr at du kan velge selv om du har lyst å være med eller ikke. Ingen andre kan velge dette for deg. Det er bare du som kan samtykke. Samtykke betyr at du sier at du synes noe er greit.



Hvis du vil delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Det betyr at det er lov å ombestemme seg, og det er helt i orden. All informasjon om deg vil da bli slettet.

Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller om du først sier «ja» og så «nei».

### **Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger**

Vi vil bare bruke informasjonen om deg til å finne ut av forskningsspørsmålene.

Vi vil ikke dele din informasjon med andre. Det er bare Andreas Kvam som har tilgang til informasjonen. Vi passer på at ingen kan få tak i informasjonen som vi samler inn om deg. Vi lagrer all informasjon på en sikker datamaskin. Vi sletter lydopptak fra intervjuet når vi har skrevet ned alt som vi har snakket om. Vi passer på at ingen kan kjenne deg igjen når vi skriver forskningsartikler. Vi vil for eksempel finne opp et annet navn når vi skriver om deg. Vi følger loven om personvern.

### **Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?**

Opplysningene anonymiseres når prosjektet avsluttes/oppgaven er godkjent, noe som etter planen er 31.mai 2022. Da vil jeg passe på at all informasjon om deg er slettet.

### **Dine rettigheter**

Hvis det kommer frem opplysninger om deg i det som vi skriver, eller har i dokumentene våre, har du rett til å få se hvilken informasjon om deg som vi samler inn. Du kan også be om at informasjonen slettes slik at den ikke finnes lenger. Dersom det er noen opplysninger som er feil kan du si ifra og be forskeren rette dem. Du kan også spørre om å få en kopi av informasjonen av oss. Du kan også klage til Datatilsynet dersom du synes at vi har behandlet opplysningene om deg på en uforsiktig måte eller på en måte som ikke er riktig.

### **Hva gir oss rett til å behandle personopplysninger om deg?**

Vi behandler informasjon om deg bare hvis du sier at det er greit og du skriver under på samtykkeskjemaet.

### **Hvor kan jeg finne ut mer?**

Hvis du har spørsmål om studien, kan du ta kontakt med meg på tlf: 91844477 eller e-post: [andrkvam@ntnu.no](mailto:andrkvam@ntnu.no).

Norsk senter for forskningsdata (NSD) har godkjent forskningsprosjektet.

Hvis du lurer på hvorfor NSD har bestemt dette, kan du ta kontakt med:

- NSD – Norsk senter for forskningsdata AS på epost ([personverntjenester@nsd.no](mailto:personverntjenester@nsd.no)) eller på telefon: 55 58 21 17.

Med vennlig hilsen

Stig Arve Sæther  
(Forsker/veileder)

Andreas Kvam  
(student)

## Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet ”Hva kjennetegner skytetreningen og ferdighetsnivået til de beste skiskytterne i Norge?” og har fått anledning til å stille spørsmål. Jeg samtykker til:

- å delta i intervju
- å dele resultater fra lasertesting og tilgang til data fra treningsdagbok

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

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(Signert av prosjektdeltaker, dato)

