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The effect of hormonal contraception on skeletal muscle hypertrophy and strength over an 8-week training intervention in recreational female strength athletes.

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Master’s Thesis in Sport Science

IDR-3901-1 Spring 2024

Acknowledgments

Writing this acknowledgment for my master´s thesis feels surreal. Earning a master´s degree is an achievement I once doubted I could reach, but here I am.

Firstly I´d like to show my appreciation for my motivational and inspiring supervisors John Owen Osborne and Karianne Hagerupsen.

Thank you, Karianne for helping with the statistics and learning STATA, without your help, I would probably still be struggling with JASP. I am also grateful for your willingness to step in and help with testing during the lab´s relocation, ensuring we completed everything on time. Your office door was open for me and my many questions, and I deeply appreciate your patience and support.

Thank you, John, for your unwavering support and belief in both me and this project. Your ability to calm me down and reassure me during moments of stress has been invaluable. You have consistently motivated and guided me in the right direction, showing faith in me and the project throughout the entire process. The trust you have shown in me is something I am incredibly grateful for.

Two people who I also need to mention are bachelor students Ine Porsanger and Vilde Kvalvik. Thank you for joining this project and for demonstrating such dedication and hard work. I truly appreciate your contributions.

Thank you to all the participants who made this study possible. Your incredible dedication and contributions exceeded all expectations. Without your involvement, this project would not have been possible. I am deeply grateful for your commitment.

I would also like to thank my friends and family for all their support and motivation. A particularly big thank you to my girlfriend, Hanna, who has supported, motivated, and believed in me when I didn’t. Without you I would never gotten through these five years, thank you.

And last but not least, I want to thank me. I want to thank me for believing in me. I want to thank me for doing all this hard work. I want to thank me for never quitting and giving up on my dreams.

Abstract

Background: There is limited research on how hormonal contraceptives (HC) may influence skeleton muscle hypertrophy and strength adaptations from resistance exercise training (RET), with no studies to date investigating long-acting reversible contraceptives (LARCs). Current research on HC shows mixed results regarding their impact on hypertrophy and strength. Furthermore, most research has been conducted on individuals with little to no prior RET experience, highlighting the need for studies on trained populations.

Purpose: This study aims to investigate the influence of HC usage on skeleton muscle hypertrophy and strength adaptations in female strength athletes with RET experience following an 8-week training intervention.

Method: Forty-one recreationally active female strength athletes in Tromsø, Norway, were recruited to investigate the effect of HC on hypertrophy and strength adaptations following an 8-week RET intervention. Participant were divided into three groups based on their current HC usage: combined oral contraceptives (COC), long-acting reversible contraceptives (LARC), or non-hormonal contraceptives (NHC). Strength and body composition were measured at baseline, at 4 weeks, and at the end of the 8-week RET intervention. Body composition was measured with dual-energy x-ray absorptiometry (DEXA), while strength was measured using a 3-repetition maximum (3RM) in the Smith machine Larsen bench press and the seal row. Differences between the HC groups and the NHC group were investigated with an analysis of covariance (ANCOVA).

Result: Of the 41 participants included in the study, 33 completed the training intervention, with 3 participants being post-hoc excluded due to HC type, leaving 30 participants for the final analysis. No significant difference was detected in body composition between the HC group and the NHC group. Significant strength increases were found in the LARC group ($p < 0.05$) and COC group ($p < 0.01$) for the 3RM seal row, when compared to the NHC group. All groups showed no significant increase in body composition from the intervention, however, all significantly increased in both strength tests from baseline to mid-test (week 1-4) and to post-test (week 1-8).

Conclusion: This study is one of the first to investigate and compare the effect of RET on hypertrophy and strength adaptations in female athletes with prior RET experience who used COCs or LARCs. The main findings were that the LARCs group significantly increased

strength in the 3RM seal row, suggesting that LARCs use may positively influence posterior back strength. Nevertheless, as this is the first study to investigate LARC usage and RET adaptations, additional comparative research is required.

Sammendrag

Bakgrunn: Det er begrenset forskning på hvordan hormonelle prevensjonsmidler (HC) kan påvirke skjelettmuskelhypertrofi og styrke tilpasninger fra motstandstrening (RET), med ingen studier som hittil har undersøkt langtidsvirkende reversible prevensjonsmidler (LARC). Nåværende forskning på HC viser blandede resultater angående deres innvirkning på hypertrofi og styrke. Videre har det meste av forskningen blitt utført på individer med liten eller ingen tidligere RET-erfaring, noe som fremhever behovet for studier på trente populasjoner.

Hensikt: Denne studien tar sikte på å undersøke påvirkningen av HC-bruk på skjelettmuskelhypertrofi og styrke tilpasninger hos kvinnelige styrke fritidsutøvere med RET-erfaring etter en 8-ukers treningsintervensjon.

Metode: 41 kvinnelige styrke fritidsutøvere i Tromsø, Norge, ble rekruttert for å undersøke effekten av HC på hypertrofi og styrketilpasninger etter en 8-ukers RET-intervensjon. Deltakerne ble delt inn i tre grupper basert på deres nåværende bruk av HC: kombinerte orale prevensjonsmidler (COC), langtidsvirkende reversible prevensjonsmidler (LARC) eller ikke-hormonelle prevensjonsmidler (NHC). Styrke og kroppssammensetning ble målt ved baseline, ved 4 uker og ved slutten av den 8-ukers RET-intervensjonen. Kroppssammensetning ble målt med dual-energy x-ray absorptiometri (DEXA), mens styrke ble målt ved bruk av 3-repetisjons maksimum (3RM) i Smith-maskinen Larsen benkpress og tetningsraden. Forskjeller mellom HC-gruppene og NHC-gruppen ble undersøkt med en analyse av kovarians (ANCOVA).

Resultat: Av de 41 deltakerne inkludert i studien, fullførte 33 treningsintervensjonen, med 3 deltakere som ble post-hoc ekskludert på grunn av HC-type, og etterlot 30 deltakere for den endelige analysen. Det ble ikke påvist noen signifikant forskjell i kroppssammensetning mellom HC-gruppen og NHC-gruppen. Signifikante styrkeøkninger ble funnet i LARC-gruppen ($p < 0,05$) og COC-gruppen ($p < 0,01$) for 3RM-seal row, sammenlignet med NHC-gruppen. Alle gruppene viste ingen signifikant økning i kroppssammensetning fra intervensjonen, men alle økte signifikant i både styrketester fra baseline til midttest (uke 1-4) og til post-test (uke 1-8).

Konklusjon: Denne studien er en av de første som undersøkte og sammenlignet effekten av RET på hypertrofi og styrke tilpasninger hos kvinnelige styrke fritidssutøvere med tidligere RET-erfaring som brukte COC eller LARC. Hovedfunnene var at LARCs-gruppen økte styrke i 3RM seal row betydelig, noe som tyder på at LARCs bruk kan ha en positiv effekt på

ryggstyrke. Likevel, siden dette er den første studien som undersøker LARC-bruk og RET-tilpasninger, kreves det ytterligere komparativ forskning.

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Abbreviations

ANCOVA = Analysis of covariance

BMC = Bone mineral content

COC = Combined oral contraceptive

CSA = cross-section area

DEXA = Dual-energy X-ray absorptiometry

FFM = Fat free mass

FM = Fat mass

FP = Follicular phase

FSH = Follicle-stimulating hormone

HC = Hormonal contraceptive

HPO = The hypoalamic pitiuiary ovarian

IUD = hormonal intra-uterine devices

LARC = Long-acting reversible contraceptive

LEAF-Q = Low energy availability in females – questionnaire

LH = luteinizing hormone

LM = Lean mass

LP = Luteal phase

MC = Menstrual cycle

NHC = non-hormonal contraceptive

OC = Oral contraceptive

POMS = Profile of mood state

PSQI = Pittsburgh sleep quality index

REK = Regional ethical committee

RET = Resistance exercise training

RIR = Reps in reserve

RM = Repetition maximum

RPE = Rate of perceived exertion

SE = Standard error

SD = Standard deviation

SHI = Subdermal hormonal implants

1 Introduction

Women's participation in sports and exercise has grown rapidly over the past half a century. For example, the proportion of female athletes in the Olympic Games has steadily increased from only 10.5% at Helsinki in 1952 to 44.4% at the 2012 London Olympics (Costello et al., 2014; Cowley et al., 2021). In fact, since winning the Olympic bid in 2005, England reported an estimated increase of more one million women participating in physical activity, and similar growth in female sport has also been observed in many other countries. Indeed, in some sports, such as road running races, women now constitute the majority of athletes, with more than half (56%) of finishers being female (Fink, 2015). This rise of the 'professional female athlete', alongside the broader trend for increased participation of women in sport and exercise in general, highlights the growing demand for relevant and targeted sports science research that focuses on optimizing the performance, health, and wellbeing of the female athlete.

Sexual dimorphism, the phenotypic difference between females and males in the same species is a particularly important and relevant factor within sports and exercise research (Costello et al., 2014). The past century has seen considerable advancements in exercise science research, resulting in enhanced athletic performance, refined coaching strategies, and better understanding of the relationship between physical activity and health in the general population. However, despite the aforementioned rise in female sport participation, sports science research has predominantly focused on male populations, leading to a persistent sex bias; succinctly highlighted in the title of a study Costello et al. (2014): *'Where are all the female participants in Sports and Exercise Medicine research?'*. In this study, authors took a random sample of sport science papers across the most prestigious and renowned sport science journals (*British Journal of Sport Medicine, American Journal of Sport Medicine, Medicine and Science in Sports and Exercise)* and found that, on average, 61% of studies had male participants, while only 39% were female.

Unfortunately, this trend in the sex data gap within sport and exercise research has remained relatively consistent. In a more recent study by Cowley (2021) the authors noted a very similar result, i.e. 34% female participation in six of the biggest sport and exercise research journals (Cowley et al., 2021). Further, only 6% of all sport and exercise science articles published had female-only participation, while studies done with male-only participants was 31%. This male bias within sport and exercise has been consistent throughout the last several decades: in competition, media, and research (Costello et al., 2014; Cowley et al., 2021; Fink, 2015). The present scarcity of relevant scientific data makes it challenging for recreational active women, female athletes, and their coaches to make appropriate and informed decisions regarding their performance. With most of the scientific data available is done on men, how can recreationally active women optimally know what is best for their training and performance?

Approximately 40% women (age 16-49) and 70% of young women in the general population use Hormonal contraceptive HC (Furu et al., 2021). HC can be descried as the utilization of exogenous sex hormones for the prevention of pregnancy (D. Nolan et al., 2023). Although HCs are also used for health or medical purposes, additionally, HCs are wildly used to manipulate menstruation for competition among athletes (Engseth et al., 2022). One study form Nolan et al (2023) even suggest that athletes using HC experience less negative symptoms compared to non-users (David Nolan et al., 2023).

Resistance exercise training (RET) is considered as the gold standard for increasing muscle hypertrophy (Hagstrom et al., 2020). Additionally, RET helps preserve and maintain bone mineral density, increase strength and reduce the of risk of metabolic syndrome, and in recent years the popularity among women participating in RET has increased (Hagstrom et al., 2020).

Currently, a limited number of studies have investigated the impact of HC on RET adaptations. In 2023, Nolan et al. conducted a systematic and multi-level meta-analysis, which remains the sole meta-analysis on this topic to date (D. Nolan et al., 2023). Based on this paper, previous research has only examined the impact of hormonal combined oral contraceptives (COC) use on RET adaptations, and no studies have considered how other types of contraceptives (e.g. LARCs) influence RET and their potential effect on strength and hypertrophy adaptations (D. Nolan et al., 2023).

The existing scientific basis around the influence of exogenous hormones on RET and muscle hypertrophy is, unfortunately, relatively limited, and there is a clear need for additional research in this area. More specifically, data from studies on HC usage and RET is of low quality, with small sample sizes, an absence of standardization, and poor familiarization(D. Nolan et al., 2023). Nevertheless, there has been a increased interest in investigating the effect of HC use on adaptive responses to RET (D. Nolan et al., 2023). To-date, there has been a lack of consistent findings regarding the impact of exogenous hormones on RET adaptations, with research showing negative (e.g., hypertrophy, strength, inflammation) (Ihalainen et al., 2019; Riechman & Lee, 2022; Ruiæ et al., 2003), positive (e.g., molecular markers) (Oxfeldt et al., 2020) and neutral (e.g., hypertrophy, strength, power) (Dalgaard et al., 2019; Dalgaard et al., 2022; Myllyaho et al., 2021; Nichols et al., 2008; Romance et al., 2019; Sung et al., 2022) outcomes for HC users versus non-users.

The majority of studies investigating the impact of HCs on RET, hypertrophy, and strength have been conducted on individuals with limited-to-no prior RET experience. Only a minority of studies have examined the effects of HCs on RET in a trained population with significant lifting experience (Nichols et al., 2008; Romance et al., 2019; Wikström-Frisén et al., 2017). Given the limited pool of research, coaches, athletes, and recreational sports enthusiasts may face challenges in making well-informed decisions about whether to initiate or discontinue contraception to optimize their athletic performance. Given the scarcity of the research exploring the potential impact of HC on performance and adaptations related to hypertrophy and strength among experienced recreational athletes, further investigation is warranted. Consequently, the aim of this study is to examine the influence of HC usage on hypertrophy and strength adaptations among recreational athletes with RET experience after an 8-week resistance training intervention.

1.1 Purpose and hypotheses

The purpose of this study was to investigate the effect of HC usage on RET and skeleton muscle hypertrophy and strength adaptations in recreational female strength athletes.

The main hypotheses were that HC would not affect skeleton muscle hypertrophy or strength adaptations.

2 Theoretical background

2.1 The menstrual cycle

The MC has been recognized as one of the ‘vital’ signs of a woman - like heart rate, respiration, blood pressure, and temperature - the menstrual history provides information about a women´s overall health (Hillard, 2014). Menstruation typically first occur at the age of 12-13 years, and is known as menarche (Biro et al., 2018; Hillard, 2014). However it is not unusual to have irregular periods for the first few years after menarche, and in sports focusing on leanness, menarche can be delayed (Hillard, 2014; Torstveit & Sundgot-Borgen, 2005). In a normal MC (eumenorrheic) there are mainly four types of hormones: estrogen, progesterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH). These hormones vary regularly throughout the cycle, as shown in Figure 1 (Davis & Hackney, 2017). The length of the MC typically varies from 21-35 days, although the cycle length often differs between cycles for the same individual, as well as between women, and what causes this difference length is still unknown (Redman & Loucks, 2005).

A eumenorrheic MC is divided into two phases, the follicular phase (FP), and the luteal phase (LP), separated by ovulation. The FP is the first phase, and it begins on the first day of menses (day 1-5), when the concentration of both progesterone and estrogen are low. Estrogen rises throughout the FP, and peaks ~1 day prior to ovulation (12-14 days after menses). Ovulation is triggered by a surge in LH, which is also accompanied by a sharp and brief increase in testosterone (Blagrove et al., 2020). The LP starts on the first day after ovulation and progesterone is released in a pulsative manner in response to the LH surge (Hackney, 2017). If fertilization occurs during ovulation, then the resultant embryo remains in the endometrium and develops into a fetus. However, if not fertilized, the corpus luteum is then degraded via proteolytic enzymes, resulting in a drop in progesterone and estrogen and the onset of menstruation, starting the whole process over again (Davis & Hackney, 2017). See Figure 1 for a graphical example of the hormonal fluctuations across a theoretical menstrual cycle.

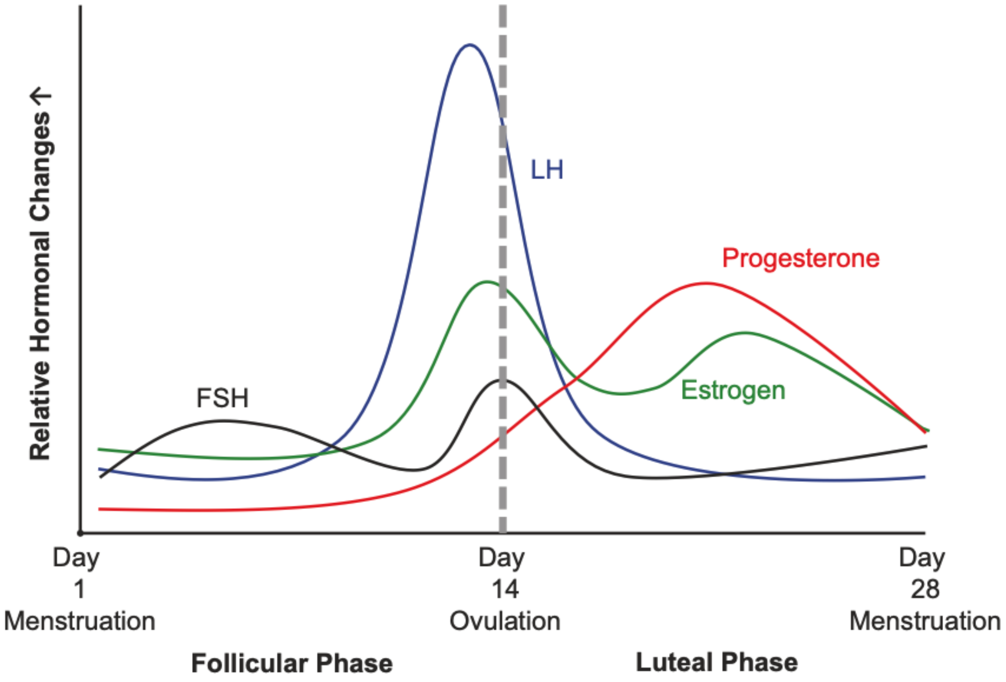

Figure 1 / The menstrual cycle

Key regulatory hormone changes associated with the menstrual cycle in a healthy eumenorrheic woman (Hackney, 2017).

2.1.1 Estrogen

The Hypotalamic-Pitiuitary-Ovarian (HPO) axis causes the release of two major reproductive hormones: estrogen and progesterone. Estrogen is produced in the ovaries of the female and is a group of similarly structured steroid hormones where their main function is reproducibility (Davis & Hackney, 2017). The estrogen group is made up of three hormones, estrone, estriol and estradiol-β-17 (Davis & Hackney, 2017). The production of these estrogen hormones is stimulated through the release of LH and FSH from the pituitary gland that binds to ovarian receptors, and induces the production and secretion of estrogen, and progesterone. The release of estrogen gradually happens during the follicular phase of the MC until the egg is released from the ovary (Figure 1), when estrogen release is downregulated and progesterone production increases (Davis & Hackney, 2017). Notably, estrogen is known to be beneficial to muscle strength and has an anabolic muscle building effect in women (Hansen et al., 2012; Lowe et al., 2010).

2.1.2 Progesterone

Progesterone is the second major reproductive hormone produced and regulated via the HPO axis and plays an important part in the MC. Progesterone is predominantly produced in the ovaries, but it is also produced in some tissues (Davis & Hackney, 2017). The production of progesterone is regulated by LH, just like estradiol-β-17. The main role of progesterone is to stabilize the endometrial lining in preparation fertilization and pregnancy (Davis & Hackney, 2017). Progesterone appears to be responsible for an increase in protein catabolism during luteal phase, feasibly attenuating muscle strength and hypertrophy, which is of potential interest to sports scientists and athletes (Oosthuyse & Bosch, 2010).

2.2 Hypothalamic-Pituitary-Ovarian (HPO) Axis

The female reproductive system is critical not only for reproductive health, but also for overall health in women. The reproductive system consists of complex interactions between feedback loops of the hypothalamus, pituitary and the ovary, all three must work together to ensure proper function (Hackney, 2017). The signaling process begins in the brain when gonadotropin-releasing hormone is released into the blood stream from the hypothalamus to the pituitary gland. This causes the release of gonadotropin hormones, specifically FSH and LH, which then stimulate the ovaries to release estrogen and progesterone (Hackney, 2017).

2.3 Hormonal contraceptive

Hormonal contraceptives (HC) can be defined by the administration of exogenous hormones that affect the endocrine regulation of the female reproductive system, which may inhibit ovulation (David Nolan et al., 2023; D. Nolan et al., 2023) Different types of contraceptives have been used for over a thousand years to prevent unwanted pregnancies and sexual transmitted diseases, however the first hormonal-based contraceptive, i.e., HC, was only approved in 1957 and was originally designed to treat menstrual disorders. HCs are administrated by a variety of delivery methods, although oral contraceptives (OC) are the most common delivery method in both the general population and athletic cohorts, with current OC use worldwide estimated at more than a 100 million women (Christin-Maitre, 2013; David Nolan et al., 2023).

In 2018, approximately 2.3 million women in Norway between the age of 16 and 49 years, reported using some form of HC, with a peak usage of 69% for women aged 20-24 years (figure 2) (Furu et al., 2021). In the athletic population there has been reported higher usage of HCs (40.2% to 49.5%) when compared with the general population (27.0% to 46.0%), and in some sport the proportion of athletes using HCs is estimated to be as high as 80% (Engseth et al., 2022; David Nolan et al., 2023).

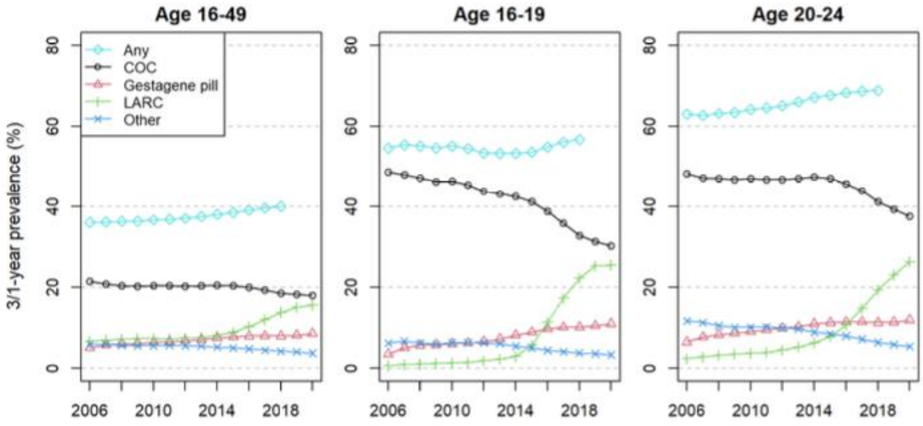

Figure 2 / *Hormonal contraceptive prevalence in Norway*

Notes: Prevalence (%) of women in different age-groups who filled prescriptions of various types of hormonal contraceptives in the period 2006-2020. Three-year prevalence for LARC, one-year prevalence for the other groups. Labels: COC= Combined oral contraceptives with estrogen and progestagen; LARC= Long-acting reversible contra- ceptives (Subdermal implant & Intrauterine device with progestagen); Other: vaginal ring, p-patch, p-injectable, COC with estrogen and antiandrogen. (Furu et al., 2021)

There are a variety of different types, brands, and generations of HCs, although they can be generally classified into two main types; 1) *progestin-only* (i.e. the synthetic version of progesterone), or 2) *combined*, which contains both progestin and estrogenic (i.e. the synthetic version of estrogen) components (David Nolan et al., 2023). In Norway, the most common HC types COCs, and long acting reversible contraceptives (LARCs) (Furu et al., 2021), which are detailed in the relevant sections below.

2.3.1 Combined oral contraceptives (COCs)

The primary method by which COCs act as a contraceptive is by suppressing ovulation. Progestin inhibits the surge of LH necessary for the release of the ovum. Additionally, progesterone thickens cervical mucus, creating a difficult passage for sperm, and decreases tubal motility, making it more challenging for sperm to reach the egg. Furthermore, it thins the endometrium, making the tissue less receptive to implantation (Kiley & Hammond, 2007). The contraceptive effectiveness of COCs is relatively high, with failure rates as low as 0.3% with “perfect” use. However, typical use failure rates are around 8% in the first year, primarily due to incorrect patient use (Kiley & Hammond, 2007), this drastically weakens the effectiveness of the COCs. Depending on type, brand, and generation, the COC can vary in the dosages of exogenous hormones across the cycle: it can be monophasic (i.e. consistent dosage), biphasic (i.e. two levels of dosage), or triphasic (i.e. three levels of dosage), and there COC’s are often categorized by the form of progestin used (D. Nolan et al., 2023).

2.3.2 Long-acting reversible contraceptives (LARCs)

Long-acting reversible contraceptives (LARCs) are long-term, reliable and highly effective hormonal contraceptives which prevent unwanted pregnancy (Bahamondes et al., 2020; Curtis & Peipert, 2017), and usage rates of LARCs have considerably increased in recent years (Furu et al., 2021; Lindberg et al., 2021). The three methods of LARCs include: hormonal intra-uterine devices (IUDs), non-hormonal copper-containing IUDs, and subdermal hormonal implants. Hormonal IUDs contain levonorgestrel hormones which inhibit ovulation and thicken cervical mucus, obstructing the penetration of sperm. The non-hormonal copper-containing IUD releases copper ions that are toxic to sperm, and notably they do not contain synthetic hormones (Curtis & Peipert, 2017). There are four types of levonorgestrel-releasing IUDs approved for use in Norway (Siri Kløkstad, 2024). The four types contains of two devices 52mg of levonorgestrel (Mirena and Liletta), one device containing 19.5mg (Kyleena), and a smaller device containing 13.5mg (Skyla) (Curtis & Peipert, 2017). Like IUDs, subdermal hormonal implants are also a very effective contraceptive methods with only an estimated 0.1% of users becoming pregnant within the first year of use. The contraceptive mechanism of subdermal hormonal implant is similar to IUDs, with a slow release of the progestin etonogestrel which inhibits ovulation and thickens the cervical mucus (Curtis & Peipert, 2017).Currently, Nexplanon is the only approved subdermal hormonal implant in Norway ((DMP), 2021).

2.4 Muscle hypertrophy

The two main mechanisms of tissue growth are hyperplasia (i.e. increase in the number of cells) and hypertrophy (i.e. increase in size of cell) (Antonio & Gonyea, 1993; Jo et al., 2009). Muscle hypertrophy can be considered distinct and separate from muscle hyperplasia (Schoenfeld, 2010). Hypertrophy is enlargement of an organ or tissue (Glass, 2005), or in this case enlargement of muscle tissue, referred to as skeleton muscular hypertrophy. Skeletal muscle hypertrophy refers to the increase in muscle fiber size due to the growth of contractile proteins (Schoenfeld, 2010), i.e. as the amount of actin and myosin increases, the cross-section of muscle fibers expands due to myofibrils growing in both number and size by incorporating new actin and myosin filaments into existing structures (McCall et al., 1996). Through RET the muscle fibers get stimulated and microtears occur, this signals the body to repair and grow bigger and stronger (Schoenfeld, 2010). Satellite cells, crucial for muscle repair and growth, are activated and fuse with the damaged fibers, donating their nuclei to increase protein synthesis, thereby enhancing the muscle's ability to synthesize new proteins and expand its cross-sectional area.

It is believed that there are three primary factors responsible for initiating these physiological adaptations for hypertrophy from RET: mechanical tension, metabolic stress, and muscle damage (Schoenfeld, 2010). Mechanically induced tension, considered the most important factor, can be caused by force generation or stretch, both essential to muscle hypertrophy, and the combination of these stimuli producing an additive effect. Recent studies have shown that mechanical tension or stretch generated by force is exceedingly effective for muscle hypertrophy, suggesting that high tension in a lengthened muscle position is highly hypertrophic (Wolf et al., 2023).

2.5 Muscle strength

Muscle strength can be defined as the force or torque a muscle can create at a specific or predetermined speed eccentrically, concentrically, or isometrically (Knuttgen & Kraemer, 1987; Mital & Kumar, 1998). Enhanced muscle strength yields beneficial effects on endurance (i.e. VO_{2max}), work economy (Beattie et al., 2014), athletic performance (Suchomel et al., 2016), bone mineral density (Howe et al., 2011), overall quality of life, and diminishes the likelihood of falls and premature mortality (Edwards & Loprinzi, 2018). Several factors determine strength and the ability to produce strength. These include anatomical factors (e.g., cross-sectional area, muscle fiber length, fiber type, and biomechanism) (Delmonico et al., 2009; Wilson et al., 2012) as well as neural factors. The central nervous system is a key factor in the development of strength and force through the degree of assembly unit recruitment, firing frequency, technique, and coordination (Sale, 1988). The combined effect of these factors determines maximum strength, highlighting the importance of understanding how to train each aspect effectively. Muscle strength is measured through a 1-repetition maximum test (1RM), one repetition with the greatest resistance (i.e. weight) one manages with the correct technique (Grgic et al., 2020). The 1RM test enables the assessment of strength in multi-joint exercises, offering the flexibility to select specific exercises for measurement. It proves highly cost-effective while also maintaining high reliability and validity in evaluating maximal dynamic muscular strength (Grgic et al., 2020).

2.6 Resistance exercise training

Participation in resistance exercise training (RET) is well known to result in a myriad of associated health benefits, such as improved mobility, better cognitive function, reduced risk of all-cause mortality, and enhanced metabolic health (Abou Sawan et al., 2023; Westcott, 2012). In addition to being a useful tool to improve health, RET is also a highly effective method to increase muscular strength and develop muscle tissue (Schoenfeld, 2010). However, as mentioned earlier, the majority of sport and exercise research has been primarily completed using males, compared to females (66% vs 34%) (Cowley et al., 2021). Some research has noted that RET may elicit different adaptive responses in women and men and that women and men possess distinct prerequisites (Jones et al., 2021; Nuzzo, 2023; Roberts et al., 2020). Furthermore, there are factors unique to women (e.g. MC, HC use) that may impact the adaptations resulting from RET (Blagrove et al., 2020; David Nolan et al., 2023; D. Nolan et al., 2023).

2.7 Female adaptations to resistance exercise training

Disregarding the influence potentially caused by endogenous or exogenous sex hormones, it has been found that untrained women who undertake progressive RET see significant skeleton muscle strength and hypertrophy gains (Hagstrom et al., 2020). Research suggests a promising dose-response relationship for upper body strength gains with a frequency of 2-4 training sessions per week, 3-4 set per exercise. Volume can be accumulated across a spectrum of training loads (i.e., light and heavy weights), and prescription methods (i.e., failure or non-failure sets), as research suggests that none of these variables appear to moderate the magnitude of upper body strength gains (Hagstrom et al., 2020). Manipulation of various training variables such as frequency, volume, and load also doesn’t seem to significantly affect the extent of hypertrophic gains reported in the literature for women, suggesting that various training approaches can lead to muscular hypertrophy (Hagstrom et al., 2020).

2.7.1 Sex hormones and resistance exercise training adaptations

There are several proposed mechanisms through which sex hormones could potentially impact adaptations to RET (D. Nolan et al., 2023). Estrogen seems to function as an anabolic hormone in women, potentially affecting pathways and processes that contribute to muscular adaptations to RET (i.e. satellite cell activity, myosin function, and protein turnover) (D. Nolan et al., 2023). Research conducted on post-menopausal women receiving estrogen replacement therapy revealed fluctuations in protein synthesis rates when compared with women not receiving hormonal therapy, suggesting that estrogen likely plays a role in modulating the regulation of protein synthesis (Dam et al., 2021; Hansen et al., 2012; D. Nolan et al., 2023).

Estrogen also potentially affects myosin protein function, as evidenced by observations of estrogen deficiency in rodent models and during menopause (D. Nolan et al., 2023). This deficiency negatively impacts the structure-function relationship of myosin and actin during activity, increasing fatiguability and diminishing force-generating capacity, thereby affecting strength (D. Nolan et al., 2023; Pellegrino et al., 2022). Some studies have suggested that estrogen may also affect satellite cell activity and function (Oxfeldt et al., 2022). However, these findings are based on rodent models, and there is insufficient research conducted on humans in this regard, with further investigation required.

There is a limited number of studies investigating the specific influence of progesterone on RET function. However, protein degradation and acid oxidation has been found to be greater during the luteal phase compared to the follicular phase, both at rest and during exercise, which may indicate that progesterone increases protein catabolism (Thompson et al., 2020). In summary, it appears that both endogenous sex hormones likely play a role in influencing female adaptations to RET. Therefore, fluctuation in these hormones (i.e. MC) may also impact the adaptations to RET. Additionally, the introduction of exogenous sex hormones through HC usage further complicates this interaction.

2.7.2 The menstrual cycle and resistance exercise training

The proposed theory that estrogen exerts an anabolic effect, while progesterone may induce a catabolic effect on skeletal muscle, implies that coordinating training sessions around menstrual cycle fluctuations of sex hormones could possibly influence adaptations to RET. Coordinating training according to the MC has been referred to as ‘phase-based training’, where training volume allocation is adjusted according to the distinct phases of the cycle (Thompson et al., 2020). However, findings from studies investigating phase-based training are contradictory. While it has been proposed that engaging in higher volumes of exercise during the follicular phase yields superior results compared to regular or luteal phase training (Sung et al., 2014), other research does not support this suggestion, reporting no discernible differences for either hypertrophy or strength (Sakamaki-Sunaga et al., 2016).

2.7.3 Hormonal contraceptives and resistance exercise training

Endogenous sex hormones play a crucial role in regulating female skeletal muscle mass and function (Alexander et al., 2022). The exogenous sex hormones from HCs (i.e. COCs) have been demonstrated to significantly decrease the endogenous levels of 17 beta-estradiol and progesterone during the mid-luteal phase of the menstrual cycle, when the concentration of endogenous estrogen and progesterone should be relatively high (Elliott-Sale, 2020). The extent to which this decline in endogenous sex hormone levels, and the rise in exogenous sex hormones, affect performance and RET adaptations is still unclear.

When examining the impact of HCs on hypertrophy or muscle growth, the existing literature remains equivocal, primarily due to the limited number of studies and the inconsistent methods use (Dalgaard et al., 2019; Dalgaard et al., 2022; Riechman & Lee, 2022; Romance et al., 2019; Sung et al., 2022; Wikström-Frisén et al., 2017). In the limited studies that have been conducted, the evidence seems to suggest that HC usage has minimal-to-no impact on muscle growth and hypertrophy (D. Nolan et al., 2023). In a study conducted by Riechman et al. (2022), the authors reported a detrimental effect of HC usage on muscle growth, attributed to the elevated androgenicity of the progestin component in the contraceptive. However, the disparity was minor; the group using non-HC gained 1.6 ± 0.2 kg in lean mass, whereas the HC group increased by 1.0 ± 0.2 kg (3.5% vs 2.1%) (Riechman & Lee, 2022). These results are consistent with the findings of Myllyaho et al. (2021), who observed a significant increase of +2.1% lean mass for the non-HC group, while the group that used HC had a non-significant increase of only 1%. However, there was no significant difference between the groups, leading to the conclusion that there were no contrasting body composition (i.e. lean mass and fat percentage) adaptations related with the use of HC (Myllyaho et al., 2021).

In contrast, other studies have indicated that HC use may positively influence hypertrophy. In a study conducted by Dalgaard et al. (2019) it was observed that the group using HC had a significant greater increase in muscle cross-section (CSA) compared to the non-HC group. The increase in muscle CSA was particularly greater in the Type-1 muscle fibers within the HC group (Dalgaard et al., 2019). In a subsequent study with improved methodology by the same research team, it was observed that there was no difference between the non-HC and HC groups in muscle CSA and fat free mass (FFM) (i.e. lean mass) (Dalgaard et al., 2022). Unlike the preceding study (Dalgaard, 2019), it can be speculated whether the group abstaining from HC experienced a more favorable alteration in body composition. This speculation arises from the fact that both groups exhibited a significant increase in FFM, however, the non-HC group decreased significantly in fat mass (FM) compared with the HC users (3.7% vs 0.8%) (Dalgaard et al., 2022). The primary distinction among these two studies lies in the generation of HC utilized, with the 2019 study using second generation COCs, while the 2022 study used third generation COCs. This discrepancy between the generation of COCs used may have contributed to the contradictory findings observed.

Similar to the research on hypertrophy and HC, there is also a limited amount of high-quality research on strength and HC. In the most extensive systematic review and multi-level meta-analysis examining hypertrophy, strength, and power adaptations when utilization COC, only 7 studies (Dalgaard et al., 2019; Dalgaard et al., 2022; Nichols et al., 2008; Riechman & Lee, 2022; Romance et al., 2019; Sung et al., 2022; Wikström-Frisén et al., 2017) fulfilled the criteria for inclusion (D. Nolan et al., 2023). Among these 7 studies there seemed to be a slight advantage favoring COC-users compared to non-users (i.e. 62% of estimated outcomes favoriting the COC condition), however the summarized standardized mean change difference was not significantly different from zero, indicating no support of a between condition difference. Overall, the meta-analysis found no evidence-based justification to advise against the use of HC in women undertaking RET with the goal of enhancing strength, hypertrophy and/or power. Similarly, there was no indication to suggest that the use of HC would be beneficial for these adaptations either (D. Nolan et al., 2023).

3 Methods

3.1 Overall study design

Forty-one recreational female athletes from Tromsø, Norway agreed to participate in a comparative study to measure the effect of 8 weeks of RET on body composition and physical strength between HC users and non-users. Participants were recruited through word-of-mouth, advertisements at training centers and the university, and social media platforms (e.g. Facebook and Instagram). Participants were divided in three groups: a) combined oral contraceptives group (COC), b) long-acting reversible contraceptives group (LARC) and, c) non-hormonal contraceptive group (NHC), based on their current HC usage or lack-thereof. To ensure that all the NHC subjects were eumenorrheic, their MC was confirmed through a urinary ovulation test (Clearblue, Swiss Precision Diagnostics GmbH, Geneva, Switzerland) given to every NHC participant, which they tested daily for 10 days following the last day of menstruation until they received a positive result. The intervention consisted of five distinct phases: baseline-testing, a 4-week training period, follow-up-testing, another 4-week training period, and a final post-testing (Figure 2). Of the 41 participants recruited, 33 completed the whole intervention and testing. The testing and training took place from October 2023 – December 2023. The study protocol was approved by the Norwegian Agency for Shared Services in Education and Research (Sikt) (ref.nr.179404), and the Regional Ethical Committee (REK) (id.nr.654537) considered the study outside of their mandate.

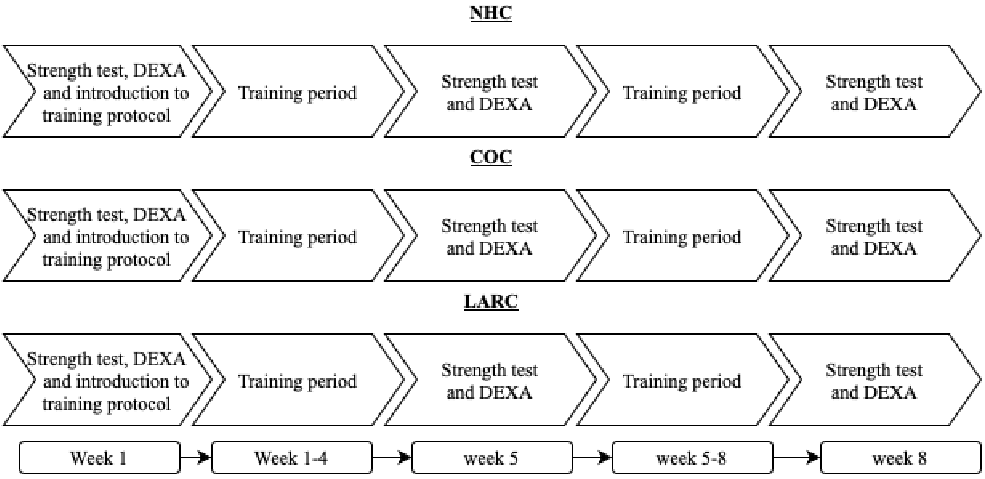

Figure 3 / Flow chart displaying the overall study protocol

Notes: The study protocol for non-hormonal contraceptive (NHC), combined oral contraceptive (COC), and long-acting reversible contraceptive (LARC) groups.

3.2 Subjects

Thirty-three recreationally trained female strength athletes between the age of 19 and 40 completed the study, with the following baseline values (mean ± standard deviation): body mass = 66.2 ± 6.8 kg, height = 167.1 ± 5.0 cm, and age = 24 ± 4 years. Out of the total sample, 24 females used HCs and the remaining nine did not use any HCs, who were considered as eumenorrheic non-users (i.e, NHC). The HC group contained a variety of different types of contraceptives. The different types of contraceptives were: combined oral contraceptive (COC) (n = 7), progestin-only pill (n = 1), long-acting reversible contraceptive (LARC) (n = 14), p-patch (n =1), and vaginal ring (n = 1). All prospective participants received information regarding the study procedures before they provided written informed consent. Inclusion criteria to participate in the study were as follows: 1) aged 18 to 40 years, inclusive; 2) at least one year of resistance training experience; 3) undertake regular resistance training (minimum of 3 times per week for the last 6 months); 4) no injury or illness for the four weeks prior to undertaking study; 5) able to bench press at least 0.4 times their body mass; and, 5) not be using athletic performance enhancing drugs.

3.3 Baseline testing

All the testing was undertaken at the two sports laboratories, located at Alfheim Stadium, Tromsø, and at UiT Campus, Tromsø. Body composition was assessed with a dual-energy x-ray absorptiometry (DEXA) scan and muscular strength was determined with 3-repetition maximum (3RM) testing in the smith machine bench-press and bench supported barbell row (seal-row). All the measurements were conducted in a specific and standardized sequence. Upon arrival at the lab, participant underwent a DEXA scan first, followed by filling out questionnaires. During this time, they were also provided with an opportunity to hydrate and eat before commencing the warm-up for the physical strength tests (Figure 3). All measurements were meticulously controlled and standardized under the supervision of the project leader. The project leader or other qualified personnel were consistently present during both the measurements and testing session.

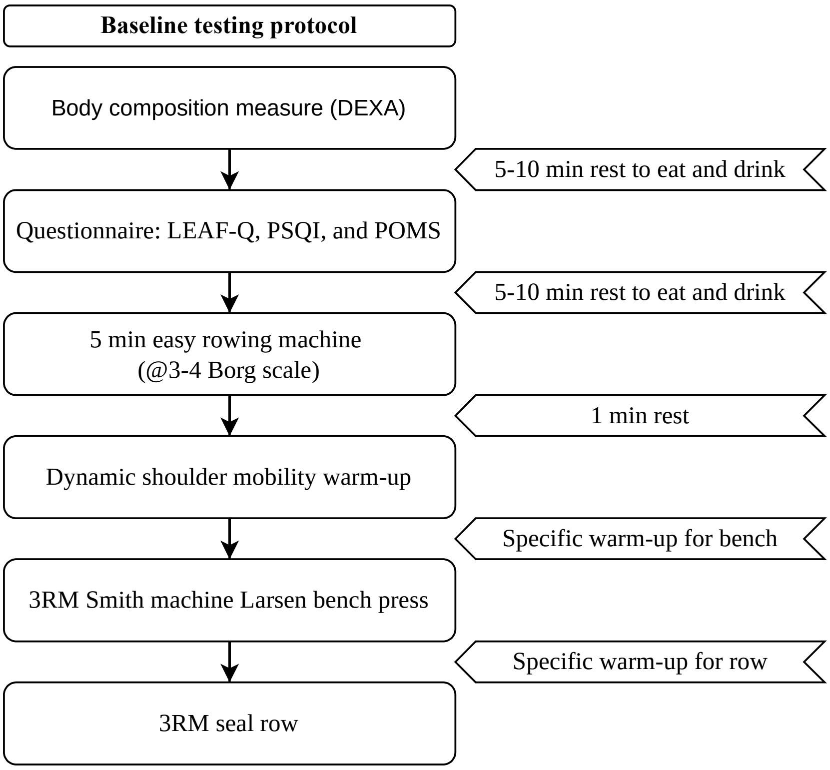

Figure 4 / Flow chart display of the test day protocol.

Notes: Testing consisted of body composition with the dual-energy x-ray absorptiometry (DEXA,) low energy availability in female's questionnaire (LEAF-Q), the Pittsburgh sleep quality index (PSQI), profile of mood state, 3 repetition maximum (3RM) smith machine Larsen bench press and, 3RM seal row. Min = minutes.

3.3.1 Dual-energy X-ray absorptiometry (DEXA)

Muscle mass and body composition were measured and analyzed with dual-energy X-ray absorptiometry (DEXA) (Lunar GE Prodigy Advamce, GE Madical Systems). DEXA scans have been shown to be a valid and reliable way to measure fat mass (FM), lean mass (LM), and bone mineral content (BMC), and are noted as the most widely used and gold-standard technique for assessing body composition (Bazzocchi et al., 2016; Lemos & Gallagher, 2017; Toombs et al., 2012). Participants were instructed to arrive for DEXA scan assessment in the morning (i.e. between 08:00-12.00 am) after an overnight fast. This precaution was taken as the intake of liquids and food, as well as physical activity or exercise, could notably influence the measurements, as noted by Bazzocchi et al. (2016): “It appears that a scan after an overnight fast (subjects fasted, rested, and euhydrated before measurements) provides the best condition for a reproducible measurement so that any small but potentially “real” change can be confidently detected” (Bazzocchi et al., 2016). All participants underwent the scan in their underwear, being requested to remove any jewelry or metal items from their bodies. The DEXA was calibrated to the manufacturer specifications every morning before testing started.

To make sure the overnight fast did not interfere with the results of the physical strength tests, all participants were allotted 15-30 minutes to consume food and beverages before the strength testing. Participants were additionally instructed to consume the same food and beverages at all testing sessions (i.e. pre-, mid-, and post-test), in order to maintain uniform conditions for the physical strength tests.

3.3.2 Strength tests

To effectively assess the strength outcomes resulting from the resistance training intervention, strength was evaluated through two specific exercises targeting the anterior and posterior musculature of the upper body. The smith machine bench-press exercise is an effective measure of the anterior musculature by engaging the pectoral, deltoid and triceps (ref??). The seal row exercise engages the dorsal, posterior deltoids and biceps muscles (Ronai, 2017), making it a valid assessment for evaluating the strength of the upper body´s posterior region. To eliminate any bias or neurologic strength advantages from participants who may be used to performing 1RM in their regular training protocol (Tillin & Folland, 2014), strength were assessed through 3RM tests, which is also can be considered valid (McCurdy et al., 2004).

3.3.2.1 Warm up

Before the participants started on the strength tests they went through a general warm up routine consisting of 5 minutes on the rowing machine at low intensity (RPE 3-4) (Borg, 1998). After 5 minutes on the rowing machine, participants completed several shoulder mobility exercises consisting of external shoulder rotation, lateral raises above the head and face pulls. Every exercise was completed once, for 10-20 repetitions with a low load (i.e. RPE 3-4).

The specific warm up consisted of 3 total sets on each exercise before they started the 3RM attempts. Participants performed 6-8 repetitions on 50%, 3-4 repetitions on 70%, and 1-2 repetitions on 85% of their estimated 1RM. The 1RM estimate was derived from the participants previous lifts in the bench-press or seal row, or lifts in similar exercises. 1RM estimation were then calculated using a 1RM calculator (ATG, 2022). The load was adjusted throughout the warmup if it was too heavy or light, based on feedback from the participants. Rest time interval between each warmup set was 2 minutes. After the last warmup set, there was a 3-minute rest before the participants started on the 3RM attempts.

3.3.2.2 Smith machine bench-press.

The smith machine (Pivot, H3310 Smith Machine) was used to eliminate technical advantages some may have from earlier bench-press training (statement, reference?). The bench press was performed as a Larsen press, with the particpant’s legs laying straight on a bench or box to prevent leg drive. Elbow joint angle and grip width were assessed and standardized to ensure that the bar made contact with the chest once the approved depth was reached. Participants were instructed to lift the bar down until it touched the chest and 90° elbow flexion was achieved, then lift the bar all the way up, and repeat this process for a total of 3 repetitions. All 3 lifts must be deemed satisfactory for the test to be considered valid. Participants undertook as many attempts as necessary, with a minimum rest interval of 3 minutes between each attempt.

3.3.2.3 Seal-row

The seal row (Pivot, 670 Pull-up Bench) was employed as a method to assess the strength of upper body posterior region due to its stability and engagement of multiple muscle groups, e.g. the latissimus dorsi, teres major, posterior deltoid, infraspinatus, teres minor, erector spine, biceps brachi, brachialis and brachioradialis (Ronai, 2017). The participants were instructed to lift the weight until they achieved 90° elbow flexion and the researcher signaled to let the weight go. Participants were given a ~1 sec break in-between each repetition, although the weight had to stay above the ground throughout the whole lift. Participants was given as many attempts as needed until they reached a 3RM, or failure. They were given a minimum of 3 minutes break between each attempt.

3.3.3 Questionnaires

To collect information on sleep, recovery, disturbance related to the menstrual cycle, energy intake, and their mood on testing day, the participants filled out three types of questionnaires. The Pittsburgh sleep quality index (PSQI) was used to record sleep quality and recovery. For assessing energy intake and disturbances related to the menstrual cycle, the low energy availability in female's questionnaire (LEAF-Q) was used. To document the participants state of mood on testing day the abbreviated profile of mood state (POMS) questionnaire was used. However, these were used for purposes outside the scope of this study.

3.4 Training protocol

All participants were assigned to the same upper body RET program. Since the RET intervention was not supervised and the participants trained at their own representative gym, all exercises in the program were selected based on their minimal setup effort, hypertrophic effect, and low technical difficulty (see Table 3 and 4). Volume, load, and intensity was adjusted to focus on hypertrophic adaptions (Schoenfeld et al., 2021). To achieve a sufficient stimulus for hypertrophy it´s essential to reach failure or near-failure (i.e., within 2 repetition of failure) (Refalo et al., 2024). Therefore, the intensity was regulated to an 8 to 10 on the Rate of Perceived Exertion (RPE) scale, corresponding to 0-2 repetition in reserve (RIR). Participants were instructed to approach the first working set close to failure (i.e. 2RIR), progressively work towards failure, and attain failure during the final working set. They were also advised to prioritize RPE/RIR over fixating solely on the number for repetitions, adjusting the load to stay within the repetition range while ensuring they remained 0-2 repetitions away from failure. The primary advantage of employing RIR over %1RM is that the RIR method aims to regulate the level of effort rather than focusing solely on the number of repetitions or the amount of load completed in a set. In this context, effort can be defined as: “the process of investing resources to complete a task, relative to the available resources or current capacity to complete the task” (Halperin et al., 2022). Participants were asked to avoid any additional training focused on upper body during the RET intervention. However, other forms of exercise and physical activity (e.g. lower body RET, hiking, football, running) were permitted. Nonetheless, participants were instructed to prioritize their participation in the upper body RET sessions. In essence, participants were instructed to structure their training regimen to prioritize the upper body sessions in regard to sleep, recovery, nutrition and other workouts or physical activity. For example, this would mean avoiding heavy leg sessions the day before an upper body session and instead scheduling it for afterwards. The two upper body sessions had to be separated by at least 48 to ensure proper recovery.

The 8-week training program comprised two upper body sessions per week, primarily targeting the pectoral and dorsal muscles. Cumulatively, the two sessions per week resulted in a weekly total of 42 effective work sets on the upper body. The training sets were allocated with 14 work sets for the pectoral muscles, 14 sets for the dorsal muscles, 8 sets for the deltoid muscles, and 6 sets for the arms (i.e. triceps and biceps) throughout the week. To ensure that all participants was familiar with the exercises they were sent a video with the exercises showing the setup and correct technique.

3.4.1 Training program

The first training session comprised of a total of 6 exercises. The session was structured with compound exercises positioned at the beginning, followed by more isolated exercises toward the end of the session (Table 3).

Table 1 / Training session one

Exercises	Set x reps	Pause (min)	RPE	Reps pr set	Weight pr set (kg)
Incline dumbbell bench press	4 x 8-10	2-3	8-10		
Lat pulldown	4 x 8-10	2-3	8-10		
Flat bench pec fly	3 x 8-10	2-3	8-10		
Incline bench dumbbell row	3 x 8-10	2-3	8-10		
Lateral raises	4 x 10-15	2-3	8-10		
Cable biceps curl	3 x 10-12	2-3	8-10		

The second training session follows the same layout as the first session, however, with a different selection of exercises (Table 4).

Table 2 / Training session two

Exercises	Set x reps	Pause (min)	RPE	Reps pr set	Wight pr set (kg)
Dumbbell bench press	4 x 6-8	2-3	8-10		
Cable row (narrow grip)	4 x 8-10	2-3	8-10		
Incline bench pec fly	3 x 8-10	2-3	8-10		
Cable pullover	3 x 8-10	2-3	8-10		
Dumbbell shoulder press	4 x 8-10	2-3	8-10		
Cable triceps push down	3 x 10-12	2-3	8-10		

3.5 Documentation of training, recovery, and sleep

Throughout the 8 week training period, all participants were instructed to fill out a spreadsheet that recorded their sleep, recovery, stress, training, and menstrual cycle (if relevant). The participants were instructed on how to fill the sheet during the baseline period and were asked to complete it daily throughout the study. The sheet contained five different sections with a variance of different measures related to training and performance (appendix 5).

Perceived recovery was measured on a scale from 0 – 10, were 0 was considered as ‘very poorly recovered’, and 10 as ‘very well recovered. Other factors related to performance and recovery were measured using the Hooper`s Index, a subjective self- analysis questionnaire regarding sleep quality, stress, fatigue, and muscle soreness relative to the subject’s well-being and recovery. The index is a summation of these four ratings (i.e., sleep quality, stress, fatigue, and muscle soreness) with subjective ratings on a scale of 1-7 from (1 point) “very very low” to (7 points) “very very high” (Hooper & Mackinnon, 1995). The Hooper Index have been suggested as one of most cost-effective ways to detect early overtraining syndrome and monitoring of training (Hooper & Mackinnon, 1995; Urhausen & Kindermann, 2002).

Monitoring of the participants sleep was completed using an abbreviated questionnaire which noted: fatigue during daytime, daytime napping, bedtime schedule, wakeup schedule, phone use before bedtime, and sleep quality. Daytime fatigue and sleep quality was measured on a scale 1-5, from 1 point, “very good”, to 5 points, “very bad”. Daytime napping was measured with a binary, yes or no, and the duration of nap. Bedtime, wake up-time, and phone use before bed was recorded with time-specific points. The purpose of the sleep tracking was outside the scope of this study but could be used as a valid tool in this study to ensure recovery and sleep was optimal for RT adaptations (Dattilo et al., 2011; Knowles et al., 2018).

3.6 Statistical analysis

Continuous variables were reported as mean ± standard deviation (SD). Categorical variables are presented numerically and as percentages (%). The adjusted mean difference is presented as coefficient ± SE (standard errors) and belonging 95% coefficient with interval from. Normality assessment was conducted using the Shapiro-Wilk test in conjunction with Q-Q plot inspection. Analysis of covariance (ANCOVA) was employed to compare variables across the three groups (non-HC, COC, and LARC), with the contraceptive groups contrasted against the non-contraceptive group. Pre-test values was used as covariant and employed in two separate analyses (pre to mid-test and pre to post-test). Paired t-test was used to detect within group differences from baseline to mid-test and post-test. The alpha value was set at $\alpha = 0.05$. All data analysis procedures were conducted using STATA (v18; StataCrop LLC, Texas, United States).

4 Result

A total of 41 participants were recruited to the study, with 33 completing the entire training intervention, and 30 being included in the final analysis. Dropouts occurred because of participants who failed to adhere to the training program (n=6), pregnancy (n=2), and the utilization of incorrect HC´s (n=3). The 30 subjects were divided into three different groups based on their HC use or non-use: a non-hormonal contraceptive group (NHC) (n=9), a combined hormonal contraceptive group (COC) (n=7), and a long-acting reversible contraceptive group (LARC) (n=14). Descriptive statistics are presented in Table 3. No statistical difference was found in body mass, body fat percentage, lean mass, or upper body lean mass within any of the groups across the pre-test, mid-test, and post-test periods. Furthermore, there were no significant disparities detected in body composition between the groups.

In the strength test, three statistical differences were observed. Specifically, the LARC group exhibited a significantly greater increase ($p = 0.048$) in the 3RM seal row of 2.9 ± 1.4kg from pre-test to mid-test compared to the NHC group. This trend continued at the post-test with a significant difference of 3.5 ± 1.5kg ($p = 0.024$). The COC group likewise demonstrated a significant increase ($p = 0.014$) in the 3RM seal row of 4.3 ± 1.6kg from the pre-test to mid-test in comparison to the NHC group. There was no significant difference observed from pre-test to the post-test, although it was close to being significant ($p = 0.074$). We detected no significant differences between the HCs groups and the NHC group in the 3RM bench press. However, there was a trend towards a significant difference for the COCs group compared to the NHCs group from baseline to post-test ($p = 0.082$) (table 6).

The paired t-test showed no within group significant difference in body composition. However, all three groups significantly increased in both the 3RM bench and 3RM seal row from baseline to mid-test (week 1-4), and from baseline to post-test (week 1-8) (table 5).

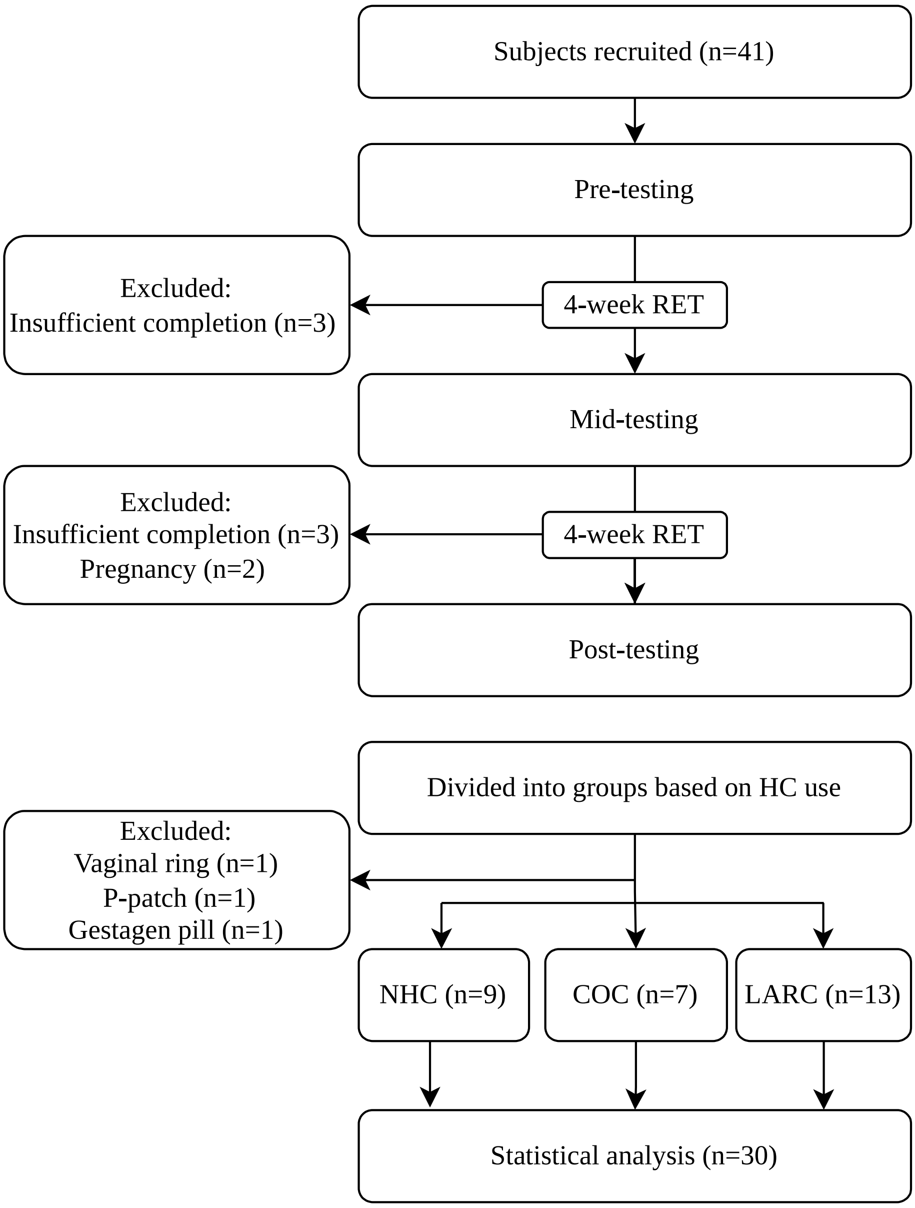

Figure 5 / *Flowchart*

Notes: The flowchart illustrates participants (n) and withdrawal throughout the whole study from recruitment to the final analysis. RET = Resistance exercise training, HC = Hormonal Contraceptiv, NHC = Non-Hormonal Contraceptives, COC = Combined Oral Contraceptive, LARC = Long-Acting Reversible Contraceptive.

Table 3 / Participants characteristics

	Total	NHC	COC	LARC
Subjects (n)	30	9	7	14
Age (year)	24 ± 4	25 ± 4.0	23 ± 2	24 ± 5
Hight (cm)	166.9 ± 5.2	167.2 ± 4.4	164.9 ± 7.2	167.9 ± 4.6
Body mass (kg)	66.8 ± 6.7	65.9 ± 8.0	66.1 ± 4.1	67.8 ± 7.1
3RM bench (kg)	46.0 ± 7.9	43.9 ± 9.8	46.3 ± 9.7	47.3 ± 5.5
3RM row (kg)	55.5 ± 7.2	55.7 ± 9.3	54.0 ± 7.2	56.1 ± 6.2
Lean mass (kg)	45.1 ± 4.1	45.2 ± 4.3	43.8 ± 4.8	45.8 ± 3.8
Upper body lean mass (kg)	21.4 ± 2.0	21.6 ± 2.3	20.8 ± 2.0	21.6 ± 1.9
Fat (%)	29.4 ± 5.9	27.9 ± 5.4	31.3 ± 5.8	29.5 ± 6.5

Descriptive data showing baseline mean ± SD values of participants characteristics for all subjects, non-hormonal contraceptive group (NHC), combined oral contraceptives group (COC), and long-acting reversible contraceptive group.

Table 4 / Subdivision of different hormonal contraception used by participants

Contraception type	Subjects	Hormone content	Norwegian designation
Non- use	n = 9	-	-
Combine oral contraceptives (COC)	n = 7	Estrogen & progesterone	Kombinasjons p-piller
Long-acting reversible contraceptives (LARC)	n = 14	Progesterone	P-stav Hormonspiral

Table displaying participants `hormonal contraceptive usage, including details on exogenous hormone content and Norwegian classification.

Table 5 /Descriptive Results

	NHC			**COC**			**LARC**		
	Pre	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
Total mass (kg)	65.9 ± 8.0	66.2 ± 8.2	65.1 ± 7.8	66.1 ± 4.0	66.8 ± 4.7	66.7 ± 5.6	67.8 ± 7.1	67.9 ± 6.6	67.6 ± 6.5
Lean mass (kg)	45.19 ± 4.31	45.77 ± 4.58	45.53 ± 4.28	43.77 ± 4.31	44.00 ± 5.06	43.71 ± 4.94	45.76 ± 3.84	46.17 ± 3.29	45.93 ± 3.19
Upper body lean mass (kg)	21.59 ± 2.27	22.02 ± 2.31	21.74 ± 2.38	20.78 ± 2.05	20.84 ± 2.42	20.48 ± 2.08	21.56 ± 1.94	21.78 ± 1.34	21.64 ± 1.66
Fat mass (%)	27.8 ± 5.4	27.9 ± 4.9	27.0 ± 5.2	31.3 ± 5.8	31.5 ± 6.2	31.9 ± 5.6	29.4 ± 6.5	29.0 ± 6.0	29.0 ± 6.7
3RM bench (kg)	43.9 ± 9.8	48.9 ± 8.9**	49.9 ± 8.5**	46.2 ± 9.6	52.0 ± 11.2**	55.0 ± 11.2**	47.3 ± 5.5	50.3 ± 7.7*	52.9 ± 6.1**
3RM row (kg)	55.6 ± 9.2	58.1 ± 9.1*	61.7 ± 7.3**	54.0 ± 7.2	60,7 ± 8.9*	63.2 ± 9.0**	56.1 ± 6.1	61.5 ±6.8*	65.7 ± 8.6**

Table presenting measurements at pre-test (pre), mid-test (mid), and post-test (post) stages for the non-hormonal contraceptive group (NHC), combined hormonal contraceptive group (COC), and long-acting reversible contraceptive group (LARC). Data for all groups are displayed as mean ± SD. Significant within group difference from baseline: * = p <0.05, ** = p <0.001.

Table 6 /Adjusted mean difference

	Baseline to mid-test			**Baseline to post-test**		
COC vs NHC	Coefficient ± SE	95% conf. - interval	P-value	Coefficient ± SE	95% conf. - interval	P-value
Total mass (kg)	0.38 ± 0.54	-0.72 - 1.49	0.48	1.32 ± 1.01	-0.76 - 3.40	0.20
Lean mass (g)	-0.42 ± 0.56	-1.57 - 0.74	0.47	-0.54 ± 0.59	-1.75 - 0.68	0.37
Upper body lean mass (kg)	-0.48 ± 0.39	-1.27 - 0.32	0.23	-0.55 ± 0.44	-1.45 - 0.35	0.22
Fat (%)	0.92 ± 0.57	-0.26 - 2.10	0.12	1.46 ± 0.76	-0.11 - 3.02	0.07
3RM bench (kg)	0.61 ± 1.78	-3.05 - 4.28	0.73	2.88 ± 1.59	-0.39 - 6.14	0.08
3RM row (kg)	4.28 ± 1.62	0.93 - 7.63	0.01*	3.23 ± 1.73	-0.34 - 6.80	0.07
LARC vs NHC						
Total mass (kg)	-0.18 ± 0.46	-1.12 - 0.77	0.70	0.72 ± 0.86	-1.05 - 2.50	0.40
Lean mass (g)	-0.13 ± 0.47	-1.11 - 0.84	0.78	-0.11 ± 0.50	-1.14 - 0.91	0.82
Upper body lean mass (kg)	-0.20 ± 0.32	-0.87 - 0.46	0.53	-0.06 ± 0.39	-0.82 - 0.69	0.86
Fat (%)	0.79 ± 0.48	-0.20 - 1.77	0.11	0.40 ± 0.64	-0.91 - 1.70	0.54
3RM bench (kg)	-2.10 ± 1.52	-5.24 - 1.04	0.18	-0.24 ± 1.36	-3.03 - 2.56	0.86
3RM row (kg)	2.86 ± 1.38	0.03 - 5.69	0.05*	3.52 ± 1.47	0.50 - 6.53	0.02*

Table presenting the adjusted mean difference of coefficient ± SE (standard errors) for COC vs NHC: combined oral contraceptive group (COC) compared with non-hormonal contraceptive group (NHC) and LARC vs NHC: long-acting reversible contraceptive group (LARC) compared with NHC. *Significant difference from control group (NHC) (p <0.05).

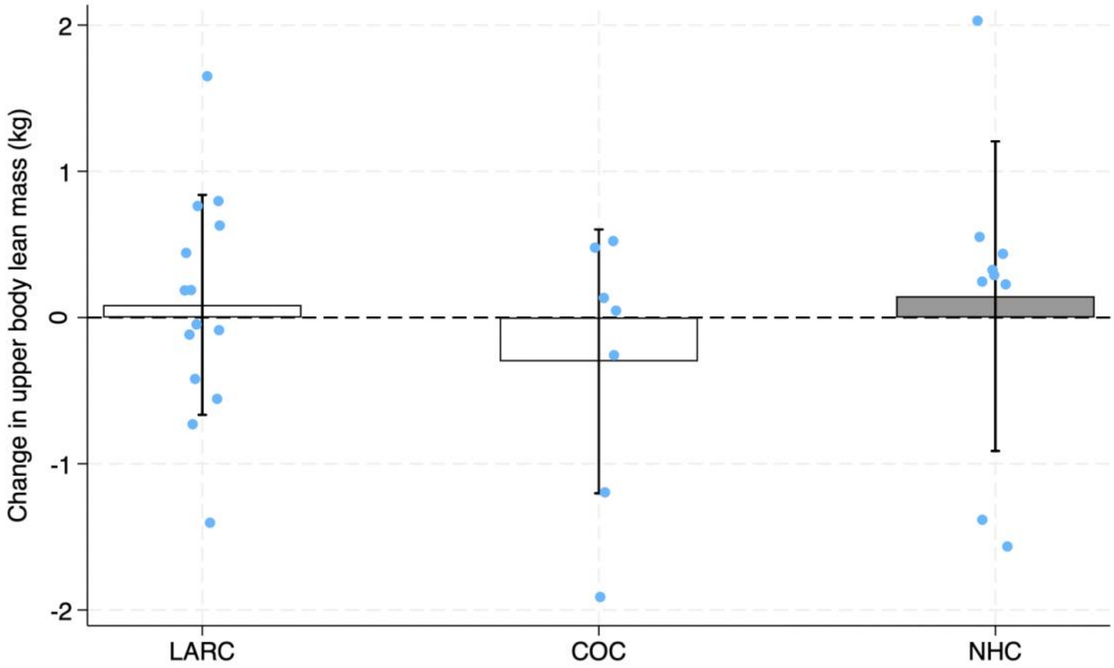

Figure 6 / Change in upper body lean mass from baseline to post-test

Notes: Figure illustrates the mean ± SD (standard deviation) change in kilograms and participants' individual change (blue dots) in upper body lean mass from baseline (week 1) to post-test (week 8) in the non-hormonal contraceptive (NHC) group, combined oral contraceptive (COC) group, and long-acting reversible contraceptive (LARC) group.

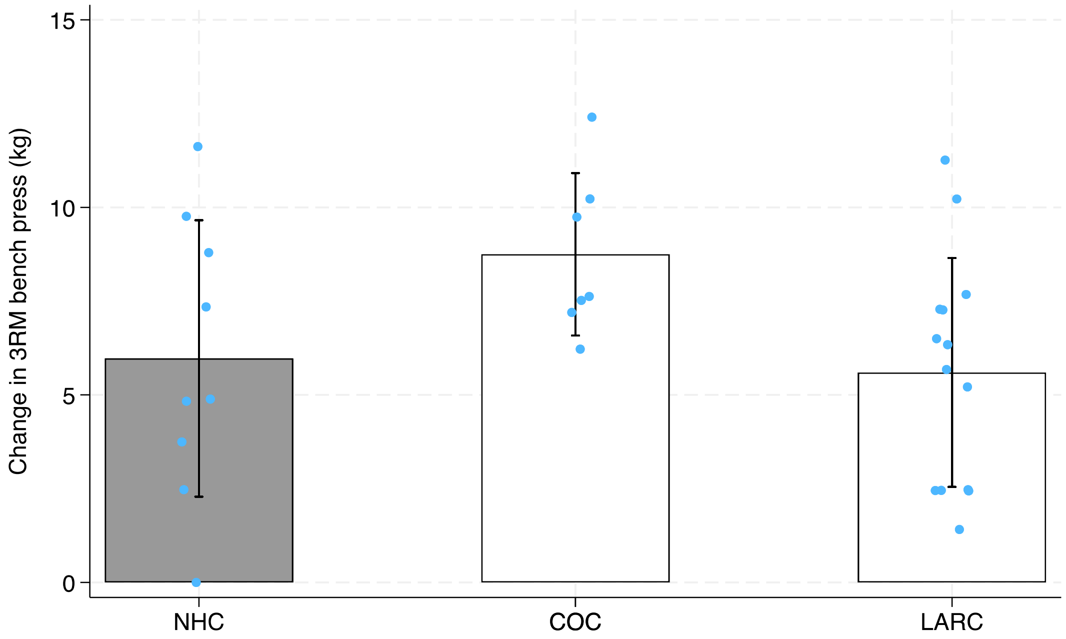

Figure 7 / Change in 3RM bench press from baseline to post-test

Notes: Figure illustrates the mean ± SD (standard deviation) change in kilograms and participants' individual change (blue dots) in the three-repetition maximum (3RM) bench press from baseline (week 1) to post-test (week 8) in the non-hormonal contraceptive (NHC) group, combined oral contraceptive (COC) group, and long-acting reversible contraceptive (LARC) group.

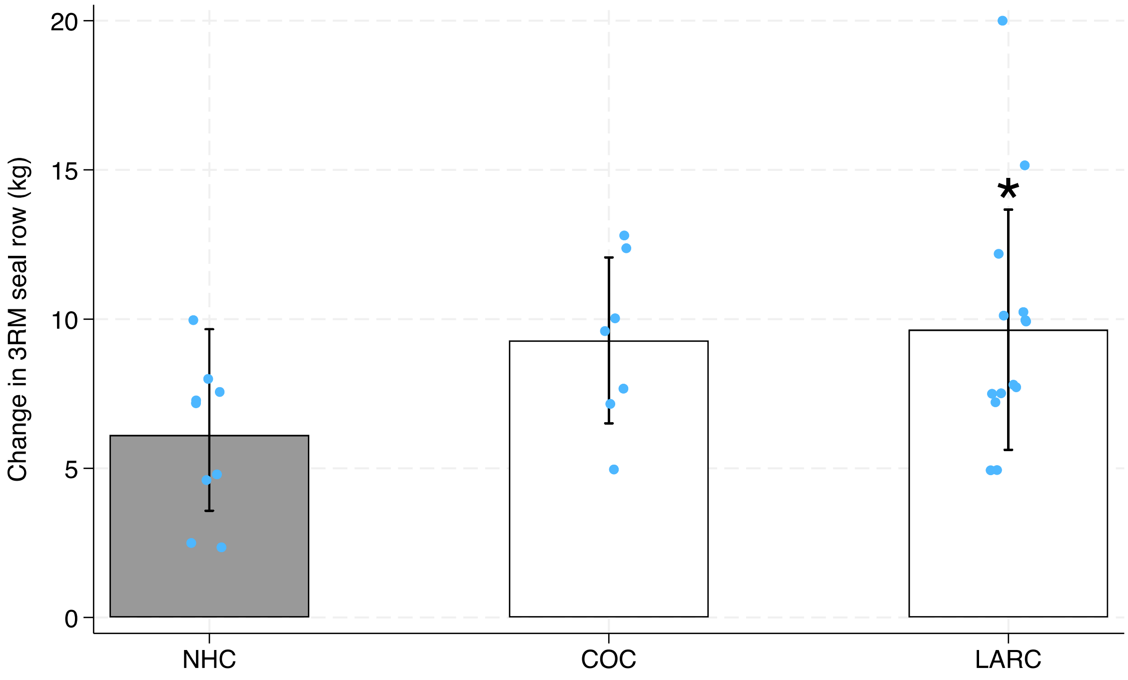

Figure 8 / *Change in 3RM seal row from baseline to post-test*

Figure illustrates the mean ± SD (standard deviation) change in kilograms and participants´ individual change (blue dots) in the three-repetition maximum (3RM) seal row from baseline (week 1) to post-test (week 8) in the non-hormonal contraceptive (NHC) group, combined oral contraceptive (COC) group, and long-acting reversible contraceptive (LARC) group. *Significant difference from the control group (NHC) ($p < 0.05$).

5 Discussion

5.1 Introduction to discussion

This 8-week RET intervention study aimed to examine the potential influence of HCs, specifically LARCs, and COCs, compared to non-HC users, on skeletal muscle hypertrophy and strength adaptations in recreational trained female strength athletes. To the best of our knowledge, this is the first study to investigate the influence of both COC and LARC use on skeletal muscle hypertrophy and strength adaptations in response to RET, and one of few to investigate HC use in a trained population. Previous studies have investigated the usage of HCs and their effect on hypertrophy and strength (Dalgaard et al., 2019; Dalgaard et al., 2022; Oxfeldt et al., 2020; Riechman & Lee, 2022; Sung et al., 2022), however, these have primarily been undertaken on individuals without prior RET experience. Several studies have explored the effect on trained individuals (Nichols et al., 2008; Romance et al., 2019; Wikström-Frisén et al., 2017), however, they have limited the HC delivery method exclusively to COCs. Thus, the present study data is both novel and unique, as it investigated the effect of HC within a RET-trained population, as well as including the utilization of LARC.

The main pre-specified hypothesis proposed that neither COC nor LARC would significantly affect hypertrophy or strength adaptations to RET in recreational female strength athletes after 8 -weeks of RET, based on outcomes from existing meta-analyses.

5.2 Summary of main findings

The main findings of this study were the significant increase in posterior strength in the LARC group compared to the NHC group following 8 weeks of upper-body RET. However, this was the only noteworthy difference observed, as the 3RM bench press showed no significant difference in either the LARC group or the COC group when compared to the NHC group. Body composition, particularly skeletal muscle hypertrophy, showed no difference between any of the groups at the end of the training intervention. The greater posterior back muscle strength increases in the LARC group, compared to NHC, which may suggest that the use of LARCs may potentially positively influence muscular strength adaptations.

5.3 Findings

5.3.1 3RM seal row

The findings in this study are somewhat contradictory to previous research. Particularly, this study observed a significant increase in posterior strength in the group utilizing LARC, when compared to the NHC group, indicating a greater posterior strength development. This strength difference emerged already after 4 weeks of training in the LARC group, and in the COC group, initially suggesting that the use of exogenous hormones, regardless of the source, may improve posterior strength when compared to non-HC users. However, at the end of the 8-week RET period, a significant difference was only detected in the LARC group, while the COC group did not show significance but trended towards an increase of significance. Previous studies have shown no significant change in strength between HC and NHC, focusing on dynamic and isometric maximal voluntary contraction leg (Dalgaard et al., 2019; Dalgaard et al., 2022; Nichols et al., 2008; Riechman & Lee, 2022; Romance et al., 2019; Sung et al., 2022), arm (Riechman & Lee, 2022) and, chest strength measures (Nichols et al., 2008; Romance et al., 2019). This study is the first to measure posterior strength and detect a significant difference in strength with HC usage.

5.3.2 3RM bench press

In contrast to the 3RM seal row, the 3RM bench press showed no significant difference in either of the groups, compared to the NHC group. Noteworthy, the COC group showed a larger absolute difference compared to the NHC group, and this difference was trending towards statistically significant ($p < 0.08$) after 8 weeks. This discrepancy complicates the interpretation of the results as it introduces conflicting measurements for strength, and conflicting results to what is seen in other studies. The observed strength difference between the LARC and NHC groups challenges the initial hypothesis and previous research (D. Nolan et al., 2023). Despite the absence of a significant increase across all strength measures, the result suggests a potential effect, indicating that LARC use may indeed play a role in enhancing the strength of the posterior back muscles compared to NHC use. Previous studies on HC have solely focused on oral contraceptives, in this regard we observed a similarity with previous research (Dalgaard et al., 2019; Dalgaard et al., 2022). The COC group displayed a larger absolute increase in muscle strength in both the 3RM row (3.23kg) and 3RM bench press (2.88kg) compared with the NHC group, yet these differences did not reach significance ($p < 0.08$ & $p < 0.07$) (table 6). These results align with the results of Delgaard et al. (2019), where a non-significant absolute increase was similarly observed in the COC group compared to the NHC group.

5.3.3 Body composition and hypertrophy

No statistically significant changes in body composition were observed in either the LARC or COC groups compared to the NHC group. There were no differences in upper body lean mass hypertrophy across the HC groups compared to the NHC group. Neither total lean mass, total body mass, nor body fat percentage presented any significant change from baseline compared to the control group. These findings align with the meta-analysis by Nolan et al. (2023). While some studies suggest a tendency for better hypertrophy increases in COC users, with significant increases in satellite cell numbers (Oxfeldt et al., 2020) and near-significant muscle gains ($p = 0.06$) (Dalgaard et al., 2019), other studies, such as Riechman & Lee (2022), found significant hypertrophy gains in the NHC users compared to COC users, linked to higher anabolic hormone levels and lower catabolic hormone concentrations (Riechman & Lee, 2022). These studies involved untrained participants over longer periods (10 weeks), which may explain the clearer differences observed. Additionally, these studies used different types and generations of COCs with varying dosages, which may lead to inconsistent results. In this study, groups were divided based on delivery method, not HC generation or brand, resulting in varying dosages within groups is problematic (D. Nolan et al., 2023). This, along with the short training duration (8 weeks) in a trained population, could explain the lack of clear differences between groups (Ahtiainen et al., 2003; Hagstrom et al., 2020). A higher absolute change in body fat percentage (1.46%) was noted in the COC group relative to the NHC group, but this difference did not reach statistical significance, although it trended towards it (p <0.07).

5.3.4 The influence of hormonal contraceptives (HC) on resistance exercise training (RET) adaptations

Several proposed mechanisms suggest how sex hormones may influence adaptations to RET (Dalgaard et al., 2022). It is understood that the administration of exogenous sex hormones aids in the downregulation of endogenous sex hormones, particularly progesterone and estrogen (D. Nolan et al., 2023). How RET adaptations are influenced by exogenous sex hormones remains unclear. So far, it is known that estrogen plays a part in mechanisms involving pathways and processes related to RET muscle adaptations such as protein turnover, myosin function and satellite cell activity. Based on estrogen deficiency studies done on rodent models and during menopause it is known that estrogen has a notable impact on skeleton muscle strength. The deficiency in estrogen negatively affects the relationship between myosin and actin during activity, reducing force production and increasing fatiguability (D. Nolan et al., 2023; Pellegrino et al., 2022). Satellite cell activity and function are also influenced by estrogen, by regulating paired box homeotic gene 7 (a marker of satellite cell number), myogenic differentiation factor D-positive fibers (a transcription factor that activates muscle-specific genes, promoting the transformation of myoblast into mature muscle fibers) and DNA uptake of bromo-deoxyuridine (indicating muscle cell proliferation). However, these findings are mostly demonstrated in ovariectomized rodent models during estrogen replacement and a limited number of studies done on humans (D. Nolan et al., 2023; Oxfeldt et al., 2022). It is worth mentioning that exogenously administrated sex hormones may differ from natural endogenous sex hormones and not be bioidentical, potentially resulting in varied effects compared to endogenous estrogen and progesterone (D. Nolan et al., 2023). The downregulation of endogenous sex hormones from the use of HC can be argued that it will negatively impact RET muscle adaptations and that the HC users may not benefit positively from it. Nevertheless, findings from this study challenges this theory and hypothesis. Furthermore, while the use of HC is primely to prevent pregnancy, but there are other reasons to why one utilizes HC. In an athlete cohort HC can be used for the alleviation of menstrual-related symptomatology and manipulation of the bleeding phase (Engseth et al., 2022; D. Nolan et al., 2023). Although we did not examine it in this study, a study by Nolan et.al. (2023) observed that women experience less negative symptoms when utilizing HC compared to those who do not use HC. Negative side effects reported were twice as high in those using HC compared to those who used HC (83.5% vs 40.0%). The most common symptoms reported by the NHC group where cramping, headache/migraine, and fatigue, which all are symptoms that potently could influence RET performance (David Nolan et al., 2023). This raises speculation HC usage might indirectly influence RET adaptations due to reduced symptoms in users, i.e., a reduction in adverse symptoms as opposed to a direct physiochemical effect on strength adaptions. Additionally, this could explain the observed significant difference in strength gains between LARC users compared to NHC users.

5.3.5 Hormonal contraceptive utilization

Originally, the focus of this study was solely on examining the impact of non-specific types of HC use on muscle hypertrophy and strength adaptations in comparison to NHC users. It was presumed that the majority of the recruited participants would be utilizing COCs, known as the most prevalent HC delivery method option (Christin-Maitre, 2013). However, upon conclusion of the training intervention and subsequent analysis, the participant cohort comprised three distinct groups: the NHC group (n=9), the COC group (n=7), and the LARC group (n=14), which constituted most of the participants. This demographic composition deviated from recent reports on contraceptive usage among females in Norway, which indicate a higher prevalence of COC usage (Furu et al., 2021). However, the predominance of LARC usage among study participants aligns with the observed surge in LARC utilization in young females (16-24 years old) between 2014 and 2020, concurrent with a decline in COC usage during the same period. This finding is consistent with a study by Engseth et al. (2022), which examined the prevalence and self-perceived experiences with the use of HC among cross-country and biathlon athletes in Norway, revealing a majority usage of progesterone-only HCs, with IUS and implants (LARC) consulting the primary modalities of usage. Given this unanticipated discovery in contraceptive use among participants, a decision was made to split the contraceptive group into two distinct subgroups to precisely scrutinize the individual effect of LARCs and COCs separately, compared to non-users. This decision was motivated due to the increase of LARC utilization among young females (Furu et al., 2021) and female athletes (Engseth et al., 2022), warranting a focused investigation into LARC-specific utilization, especially given the lack of research examining the impact of LARC utilization on strength and muscle hypertrophy.

5.4 Methodological considerations

Reflecting on certain methodological consideration necessary to place the findings of this study in an appropriate context requires further discussion. Looking at the duration of the training duration of this study - 8 weeks - it can be argued that such a short timeframe is simply insufficient to yield significant muscle adaptations. On average, women experience a 25%

increase in muscle strength after 15 weeks of training, while lean mass hypertrophy only increase 3.3% (1.4kg) in the same time period (Hagstrom et al., 2020). Thus, to ascertain any significant difference if any in skeletal muscle hypertrophy adaptations between non-users and HC users, the training period would likely to have been extended to a longer duration.

This study also utilized participants with prior experience in RET, in an effort to enhance the relevance for an athletic population, improving external validity. This aspect can both be viewed as a strength and weakness of the study as there have been only three prior studies to date that have investigated the effect of HC use on an athletic/trained population (Romance et al., 2019; Sung et al., 2022; Wikström-Frisén et al., 2017). However, the use of a recreationally trained sample also highlights the limited 8-week training intervention duration since trained athletes experience only a moderate increase in skeletal muscle strength and hypertrophy compared to an untrained population (Ahtiainen et al., 2003). Thus, considering the population of this study, the 8-week duration of the training intervention may not be sufficiently long enough to discern significant differences between HC users and non-users, particularly concerning hypertrophy. Potentially a longer duration, (e.g., 12 weeks+), would have provided enough stimuli to induce a training effect on these participants and permit a comparison of adaption potentials and changes between the groups

The group distribution was categorized based on delivery method, not on the type of brand or generation of contraception participants utilized. This distinction is not relevant in the LARC group as there is only one brand that is currently approved and utilized (i.e. Nexplanon) ((DMP), 2021; Curtis & Peipert, 2017). However, in the COC group, this lack of differentiation may have result in various concentration in exogenous sex hormones based on generation and brand type, thus resulting in a non-homogenous COC group. The inclusion of estrogen and progesterone contraceptive users alongside progesterone-only users strengthens the study. Given the potential influence of different type of exogenous sex hormones on RET adaptations, this distribution of different type of HC utilization among participants arguably strengthens the study´s validity.

5.5 Limitations

It must be noted that this study had several limitations. Firstly, one major limitation of the study lies in the small sample size, consequently diminishing the statistical power of the study to identify group differences. A sample size of 30 participants is a relatively small, especially when it is to be divided into three groups. Therefore, it is desirable to have a larger sample size as the individual response to training can vary (Ahtiainen et al., 2016), and the potential negative symptoms from HC usage may vary from each individual (David Nolan et al., 2023). This raises the question of whether the result might erroneously appear negative, indicating a type 2 error. Due to the specific criteria needed for the NHC group (well-trained young women who do not utilize HC) recruitment for this research project was particularly challenging, similar to the difficulties faced in similar female sports science research (Nichols et al., 2008). As of the latest report on HC use in Norway, only 30% of young females (16-24 years) do not utilize HC (Furu et al., 2021), which narrows the selection of women who are suitable as participants. Moreover, they also had to have prior experience with RET and a certain level of strength and fitness to be included for participation. All these specific inclusion criteria narrowed down potential participants to a very small group of specific women who were suitable for participation.

Another limitation was the lack of blood sample collection to confirm the hormone level throughout the menstrual cycle for the NHC group. This would be the best way of mapping out the menstrual cycle of the participants and knowing for sure if they are emunormerical. Mapping out the hormonal levels throughout the cycle by blood sample is the gold standard and most accurate (Elliott-Sale et al., 2021; Schaumberg et al., 2017). But it is expensive and therefore something that's out of this thesis's economical scope.

The lack of supervision during the training intervention limits the study's validity because one can't know for sure if the participants were consistent and adherence to the prescribed training program. Performance has been shown to decline when the training is not supervised (Fennell et al., 2016). This can also lead to variability in the exercise selection, intensity, and total volume performed. Additionally, supervised training. allows for real-time feedback and adjustments, optimizing the training and potentially enhancing the outcome.

The lack of familiarization to the strength tests and training protocol can lead to a variability in performance, as participants may not be accustomed to the specific training protocol or measures of strength, leading to inconsistent performance across training and testing sessions (Dias et al., 2005). When lacking familiarization with the protocol, a learning effect can become a confounding factor and interfere with the result. These interferences can be improper technique or inconsistent application of force or resistance, incorrect execution of the exercises can lead to noise in the data and reduce the precision of the strength measurements (Dias et al., 2005). However, since the participants were trained, they likely had prior experience with the testing measures, limiting the learning effect.

The gold standard externally valid method for measuring maximal strength is the 1RM (Grgic et al., 2020). However, the present study instead used the 3RM to measure strength development. This selection was to eliminate any neuromuscular advantages that some participants could have had from prior experience with 1RM strength tests (Tillin & Folland, 2014). The 3RM can also be considered a relabel and valid measure of strength (McCurdy et al., 2004), however, it may be more difficult to generalize the results as 1RM is the preferred measurement of strength in the literature.

The grouping of participants utilizing HCs was split into two different groups based on the delivery method, and not brand and generation of contraceptive. Dosages and formulas of exogenous sex hormones (i.e. estrogen and progesterone) vary based on what type of brand and generation of HC, and this is particularly relevant for COCs (ref). The LARC group consisted of participants utilizing IUDs or subdermal hormonal implants. These two LARCs differ in dosages, with IUDs providing smaller dosages of exogenous hormones due to the local application, compared to SHIs. IUDs can also vary in dosage based on brand (Curtis & Peipert, 2017), which again can affect the potential effect.

The DEXA scan is known as a reliable and valid tool for assessing body composition and the gold standard for bone density measuring (Bazzocchi et al., 2016; Lemos & Gallagher, 2017). However, when it comes to measuring muscle tissue and regional measurements, an MRI is a more accurate tool (Lemos & Gallagher, 2017). The DEXA is also sensitive to muscle hydration, and if the preparation protocol is not completed correctly, this can influence the result. However, we standardized the hydration, food intake, and timing in advance of the DEXA scan, so all possible confounding factors were controlled for (Bazzocchi et al., 2016; Lemos & Gallagher, 2017).

5.6 Strengths

A major strength of this study is the fact that it’s the first study to investigate the potential affect that LARC have on RET. Until now, few studies have investigating HC and RET, but these have solely focused on oral contraceptives. With the increasing use of LARCs (Engseth et al., 2022; Furu et al., 2021), this makes the population of the study more homogenized and relevant. In addition, participants were familiar with strength training and were considered “well-trained”. Conducting research on individuals with a strength training background is crucial for generating findings applicable to athletes and coaches, as responses to strength training can vary based on previous experience and training status (Ahtiainen et al., 2003). Further, since the population of the study were recreational strength athletes, and because of their RET experience, they were familiar with the strength tests and exercises in the training program. Familiarization with exercises can positively affect the performance (Dias et al., 2005). Although the study did not include a familiarization phase, the participants were experienced lifters and already familiar with RET and the exercises, which can be considered a strength.

All the measurements in this study were high-quality if performed properly. The DEXA scan is known to be precise, and clinically relevant, and has been previously utilized in similar studies (Dalgaard et al., 2022; Romance et al., 2019; Wikström-Frisén et al., 2017). The DEXA technique is widely used in clinical practice and scientific research, it is deemed as one of the best measures of body composition (Bazzocchi et al., 2016; Lemos & Gallagher, 2017), and it is a valid and relabel tool to measure lean mass and skeleton muscle hypertrophy. Urinary ovulation testing was used to track the menstrual cycle of the participants in the NHC group, and ensure they were eumenorrheic, and therefore experiencing the hormonal fluctuations associated with a normal menstrual cycle. Urinary ovulation testing detects the surge in LH that occurs before ovulation and is a reliable indicator and convenient way of detecting the different phases of the menstrual cycle and ensuring no severe menstrual cycle disturbances (Su et al., 2017).

There was a high retention among the participants in this study. Of the total 41 participants recruited only 8 subjects dropped out (Figure 4). This both increases the validity and reliability of the study while showcasing that conducting female sports science research is certainly possible. The commitment of the participants also reflects that the training program was achievable and fit for the targeted population. This helps to strengthen the argument against the sex data gap and male bias within sports science research (Costello et al., 2014; Cowley et al., 2021), demonstrating that females are fit to participate in training interventions.

5.7 Implications for future research

To date, there are only a handful of studies that have investigated at the potential impact of HC use on skeletal muscle hypertrophy and strength adaptations from RET, with even fewer focusing on trained populations. As previously mentioned, this study is the first to investigate LARCs potential impact, marking an initial first step towards closing the knowledge gap. However, more research is still needed, both within trained and untrained populations. It’s also worth mentioning that this study did not separate LARCs into IUDs and subdermal hormonal implant users, and thus it is recommended that future research take this into account.

This study involved a relatively short training duration of 8 weeks, and only included a total of 30 participants, reducing statical power and impairing the ability to identify significant group differences. Future studies should consider longer training interventions with larger sample sizes to be able to capture muscle adaptations, such as hypertrophy, that take a longer to occur. The inclusion of other, additional measures, would also be is also desirable, such as muscle force and power production, hormone levels, and recording self-perceived negative symptoms related to RET and the MC.

6 Conclusion

This study was the first to investigate both COCs and LARCs use on hypertrophy and strength adaptations in women with prior RET experience. The main findings in this study indicate that LARC usage appear to positively affect upper body posterior strength, but not anterior upper body strength or muscle growth, compared to non-users. COC usage does not appear to affect muscle growth or strength. However, due to a small sample size, these findings may not be generalizable to the broader population. For COC use, the results correspond with previous research, but due the lack of research on LARC use, more research is needed to reach to a clear conclusion.

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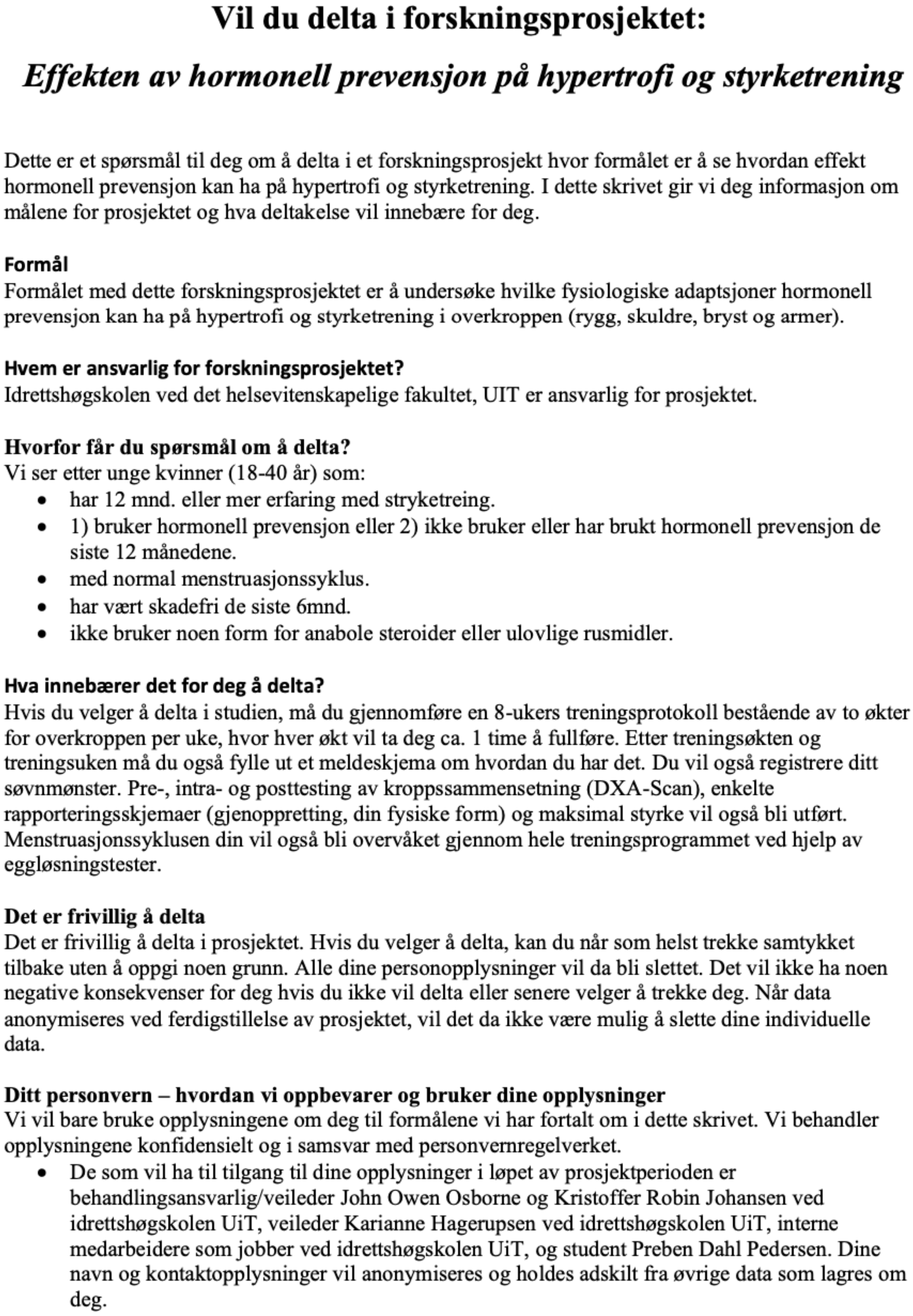
Appendix 1 – Table of studies investigating HCs effect on skeleton muscle hypertrophy and strength from RET

Study	Subjects (n)	Age (years)	Traning status	Intervention duration	Outcomes	HC vs NHC	Study conclusion
(Dalgaard et al., 2019)	COC=14 NHC=14	24 ± 1 24 ± 1	Untrained	10 weeks	Hypertrophy Strength	↔ / ↑ ↔	COCs use was associated with a trend towards greater hypertrophy increase and a significant increase in type 1 muscle fiber area compared to NHCs group. COCs did not influence strength.
(Dalgaard et al., 2022)	COC=20 NHC=18	24 ± 2 24 ± 3	Untrained	10 weeks	Hypertrophy Strength Power	↔ ↔ ↔	COCs did not significantly increase muscle hypertrophy nor strength compared to NHCs.
(Sung et al., 2022)	COC=34 NHC=40	22 ± 2 25 ± 5	Untrained	12 weeks	Hypertrophy Strength	↔ ↔	The effect of RET on muscle strength, thickness, fiber size, and composition were similar regardless of their HC use.
(Nichols et al., 2008)	COC=13 NHC=18	20 ± 1 19 ± 1	Trained	12 weeks	Strength	↔	COCs use did not affect strength gains beyond the RET protocol.

Study	Subjects (n)	Age (years)	Traning status	Intervention duration	Outcomes	HC vs NHC	Study conclusion
(Oxfeldt et al., 2020)	COC=20 NHC=18	24 ± 2 24 ± 3	Untrained	10 weeks	Hypertrophy	↔	COCs use increased skeleton muscle MRF4 expression and satellite cell number compared to NHCs users.
(Riechman & Lee, 2022)	COC=34 NHC=38	21 ± 3 20 ± 2	Untrained	10 weeks	Hypertrophy Strength	↓ ↔	COCs use impairs hypertrophy gains in young healthy untrained women, but the effect may depend on the type of COCs.
(Romance et al., 2019)	COC=12 NHC=11	27 ± 4 28 ± 4	Trained	8 weeks	Hypertrophy Power Strength	↔ ↔ ↔	COCs use dose not affect body composition nor strength in trained young women.
(Wikström-Frisén et al., 2017)	Group 1: COC=11 NHC=8 Group 2: COC=10 NHC=9 Group 3: COC=11 NHC=10	25 ± 4 25 ± 3 25 ± 4	Trained	16 weeks	Strength Hypertrophy Power	↔ ↔ ↔	High-frequency periodized leg training during the first 2 weeks of the NHC/COC cycle was more beneficial for power, strength and lean leg mass gains compared to high-frequency training during the last 2 weeks.

Table present studies that have investigated RET and HC use. ↑ = significant difference favoring OCP group; ↔ = No significant difference between groups; ↓ = significant difference favoring OCP non-users group. COC = Combined Oral Contraceptive, LARC = Long-Acting Reversible Contraceptive, NHC = Non-Hormonal Contraceptive. Mean ± SD (Standard deviation). Based on the table from Nolan et al. (2023) (D. Nolan et al., 2023).

Appendix 2 - Consent form



Vil du delta i forskningsprosjektet:

Effekten av hormonell prevensjon på hypertrofi og styrketrening

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å se hvordan effekt hormonell prevensjon kan ha på hypertrofi og styrketrening. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

Formålet med dette forskningsprosjektet er å undersøke hvilke fysiologiske adaptsjoner hormonell prevensjon kan ha på hypertrofi og styrketrening i overkroppen (rygg, skuldre, bryst og armer).

Hvem er ansvarlig for forskningsprosjektet?

Idrettshøgskolen ved det helsevitenskapelige fakultet, UIT er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?

Vi ser etter unge kvinner (18-40 år) som:

- har 12 mnd. eller mer erfaring med styketreing.
- 1) bruker hormonell prevensjon eller 2) ikke bruker eller har brukt hormonell prevensjon de siste 12 månedene.
- med normal menstruasjonssyklus.
- har vært skadefri de siste 6mnd.
- ikke bruker noen form for anabole steroider eller ulovlige rusmidler.

Hva innebærer det for deg å delta?

Hvis du velger å delta i studien, må du gjennomføre en 8-ukers treningsprotokoll bestående av to økter for overkroppen per uke, hvor hver økt vil ta deg ca. 1 time å fullføre. Etter treningsøkten og treningsuken må du også fylle ut et meldeskjema om hvordan du har det. Du vil også registrere ditt søvnmønster. Pre-, intra- og posttesting av kroppssammensetning (DXA-Scan), enkelte rapporteringsskjemaer (gjenoppretting, din fysiske form) og maksimal styrke vil også bli utført. Menstruasjonssyklusen din vil også bli overvåket gjennom hele treningsprogrammet ved hjelp av eggløsningstester.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg. Når data anonymiseres ved ferdigstillelse av prosjektet, vil det da ikke være mulig å slette dine individuelle data.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

- De som vil ha til tilgang til dine opplysninger i løpet av prosjektperioden er behandlingsansvarlig/veileder John Owen Osborne og Kristoffer Robin Johansen ved idrettshøgskolen UiT, veileder Karianne Hagerupsen ved idrettshøgskolen UiT, interne medarbeidere som jobber ved idrettshøgskolen UiT, og student Preben Dahl Pedersen. Dine navn og kontaktopplysninger vil anonymiseres og holdes adskilt fra øvrige data som lagres om deg.

- Dine navn og kontaktopplysninger vil avidentifisert og holdes adskilt fra øvrige data som lagres om deg. Data vil kun oppbevares på maskinvare tilhørende UiT eller i databehandlingstjenester (Onedrives skytjeneste) som har avtale med UiT og som krever tofaktorautentisering for å logge på.
- Resultatene i prosjektet vil kunne publiseres i en masteroppgave og som vitenskapelig artikler. Data som publiseres vil være anonymisert og det vil ikke være mulig å gjenkjenne dine resultater.
- De fullstendig anonymiserte dataene kan også brukes til fremtidige vitenskapelige artikler.

Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?
Opplysningene anonymiseres når prosjektet avsluttes/oppgaven er godkjent, noe som etter planen er 20.06.2024.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Idrettshøgskolen UiT har Sikt – Kunnskapssektorens tjenesteleverandør vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke opplysninger vi behandler om deg, og å få utlevert en kopi av opplysningene
- å få rettet opplysninger om deg som er feil eller misvisende
- å få slettet personopplysninger om deg
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger

Hvis du har spørsmål til studien, eller ønsker å vite mer om eller benytte deg av dine rettigheter, ta kontakt med:

- Idrettshøgskolen UiT ved Kristoffer Robin Johansen, Stipendiat, tlf 94059207, Epost: kjo122@uit.no
- Idrettshøgskolen UiT ved John Owen Osborne, Førsteamanuens, Epost: jos042@uit.no
- Idrettshøgskolen UiT ved Karianne Hagerupsen, Universitet lektor, Epost: karianne.hagerupsen@uit.no
- Student Preben Dahl Pedersen, tlf 98442389, Epost: ppe040@uit.no
- Vårt personvernombud: Joakim Bakkevold, personvernombud@uit.no

Hvis du har spørsmål knyttet til vurderingen som er gjort av personverntjenestene fra Sikt, kan du ta kontakt via:

- Epost: personverntjenester@sikt.no eller telefon: 73 98 40 40.

Med vennlig hilsen

John Owen Osborne (Forsker/veileder)	Kristoffer Robinson (Forsker/veileder)	Karianne Hagerupsen (Forsker/veileder)	Preben Dahl Pedersen (Master student)

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet '*Effekten av hormonell prevensjon på hypertrofi og styrketrening*' og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i ett 8 ukers styrketreningsprogram for overkroppen;
- ☐ å delta i fysiske tester som innebærer maksimal styrke, eksplosiv styrke, helkroppsscan (DXA) for å måle fettfri og fettmasse, før og etter gjennomført treningsprogram;
- ☐ å delta i å registrere din fysiske form, søvn, restitusjon og spisemønster;
- ☐ at student Preben Dahl Pedersen kan lagre opplysninger om meg til prosjektet

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

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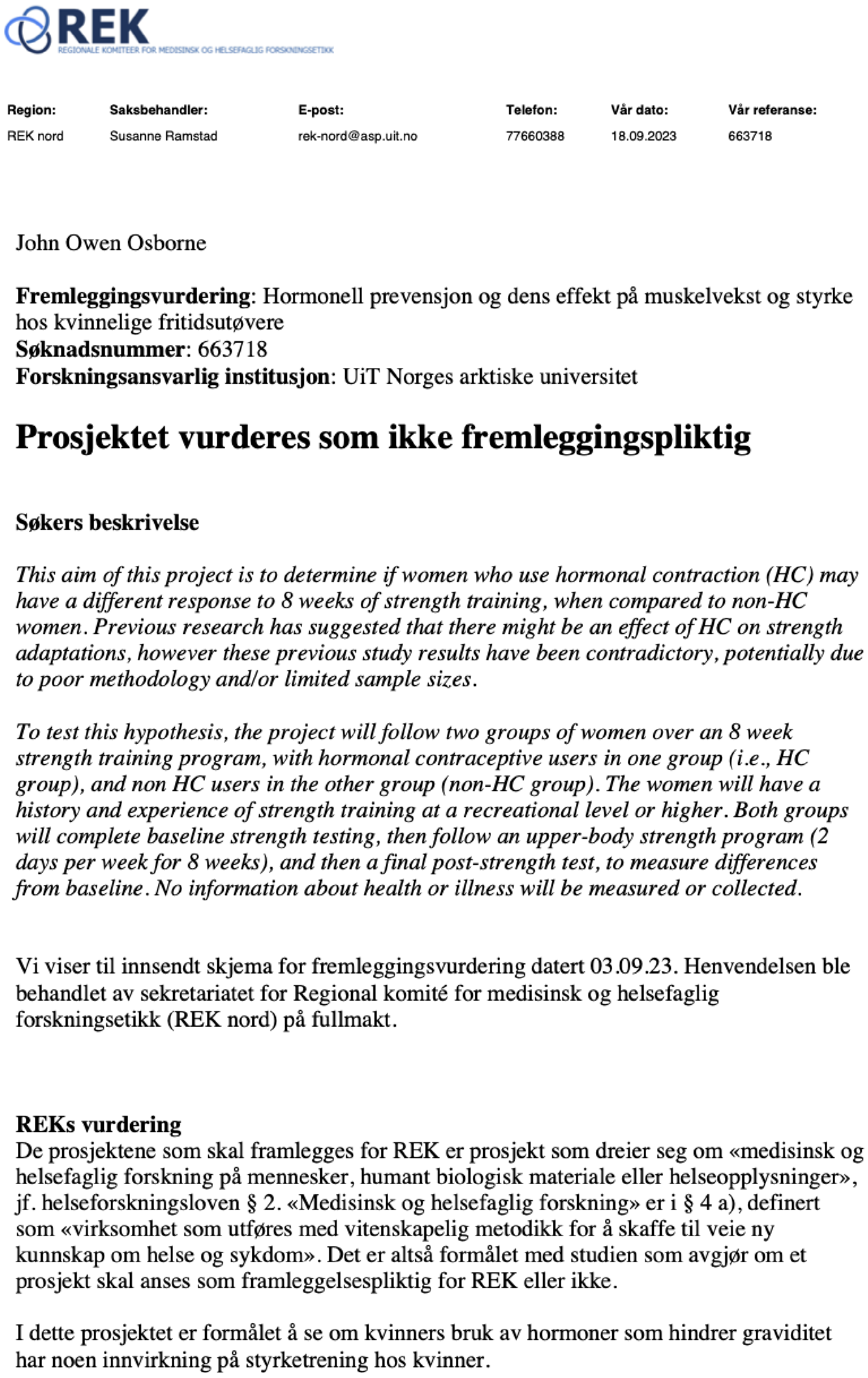
(Signert av prosjektdeltaker, dato)

Appendix 3 - REK application



REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	E-post:	Telefon:	Vår dato:	Vår referanse:
REK nord	Susanne Ramstad	rek-nord@asp.uit.no	77660388	18.09.2023	663718

John Owen Osborne

Fremleggingsvurdering: Hormonell prevensjon og dens effekt på muskelvekst og styrke hos kvinnelige fritidsutøvere
Søknadsnummer: 663718
Forskningsansvarlig institusjon: UiT Norges arktiske universitet

Prosjektet vurderes som ikke fremleggingspliktig

Søkers beskrivelse

This aim of this project is to determine if women who use hormonal contraction (HC) may have a different response to 8 weeks of strength training, when compared to non-HC women. Previous research has suggested that there might be an effect of HC on strength adaptations, however these previous study results have been contradictory, potentially due to poor methodology and/or limited sample sizes.

To test this hypothesis, the project will follow two groups of women over an 8 week strength training program, with hormonal contraceptive users in one group (i.e., HC group), and non HC users in the other group (non-HC group). The women will have a history and experience of strength training at a recreational level or higher. Both groups will complete baseline strength testing, then follow an upper-body strength program (2 days per week for 8 weeks), and then a final post-strength test, to measure differences from baseline. No information about health or illness will be measured or collected.

Vi viser til innsendt skjema for fremleggingsvurdering datert 03.09.23. Henvendelsen ble behandlet av sekretariatet for Regional komité for medisinsk og helsefaglig forskningsetikk (REK nord) på fullmakt.

REKs vurdering

De prosjektene som skal framlegges for REK er prosjekt som dreier seg om «medisinsk og helsefaglig forskning på mennesker, humant biologisk materiale eller helseopplysninger», jf. helseforskningsloven § 2. «Medisinsk og helsefaglig forskning» er i § 4 a), definert som «virksomhet som utføres med vitenskapelig metodikk for å skaffe til veie ny kunnskap om helse og sykdom». Det er altså formålet med studien som avgjør om et prosjekt skal anses som framleggelsespliktig for REK eller ikke.

I dette prosjektet er formålet å se om kvinners bruk av hormoner som hindrer graviditet har noen innvirkning på styrketrening hos kvinner.

Det fremstår som at formålet omhandler idrettsprestasjon.

Konklusjon
Selv om funnene i studien vil kunne gi en helsemessig gevinst for idrettsutøvere, faller ikke prosjektet ikke inn under definisjonen av de prosjekt som skal vurderes etter helseforskningsloven.

Prosjekter som faller utenfor helseforskningslovens virkeområde kan gjennomføres uten godkjenning av REK. Det er institusjonens ansvar å sørge for at prosjektet gjennomføres på en forsvarlig måte med hensyn til for eksempel regler om taushetsplikt og personvern.

Med vennlig hilsen

Henriette Birkelund
sekretariatsleder

Susanne Ramstad
seniorrådgiver

Kopi til:
UiT Norges arktiske universitet
Preben Dahl Pedersen

Appendix 4 – Participant information

Prosjekt tittel

Engelsk:

The effect of hormonal contraception on muscle strength and hypertrophy over an 8-week training intervention in female recreational athletes.

Norsk:
Effekten av hormonell prevensjon på muskelstyrke og hypertrofi over en 8-ukers treningsintervensjon hos kvinnelige fritidsstyrkeutøvere.

Bakgrunn

Selv om halve verdensbefolkningen består av kvinner ser vi fortsatt skuffende lite til kvinners representasjon i trening og idrettsvitenskapen (Cowley et al., 2021). Denne skjeve fordelingen av kjønn i forskningslitteraturen gjør det vanskelig for kvinnelige utøvere og trenerne deres å ta gode kunnskapsbaserte beslutninger angående trening og prestasjon når nesten all forskning er gjort på menn. Man vet at det er store biologiske, fysiologiske og hormonelle forskjeller mellom kjønnene. Men kanskje den største forskjellen som vil påvirke prestasjonen og adopsjoner ved trening er den kvinnelige menstruasjonssyklusen (Elliott-Sale et al., 2021).

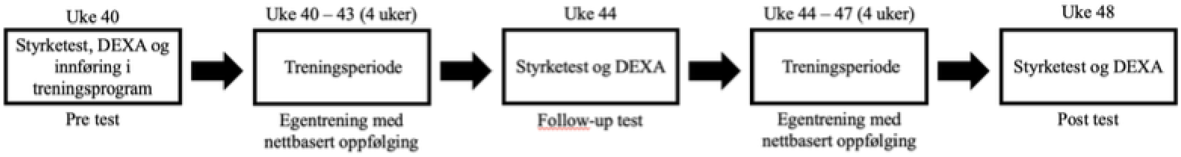
Menstruasjonssyklusen kan referees til reguleringen av en rekke forskjellige sex-hormoner (hovedsakelig østrogen og progesteron) hos friske voksne kvinner (LEBRUN et al., 1995). Østrogen er et av de kvinnelige hormonene som har vist seg å påvirke og regulere styrke og muskelvekst tilpasninger på grunn av dens anabolske effekt (Blagrove et al., 2020). Bruken av hormonell prevensjon (HP) har økt, til å forhindre graviditet eller dempe uønskede menstruasjons symptomer (Martin et al., 2018; Taim et al., 2023). Nye tall viser at så mange som 40% av kvinner i Norge bruker HP(Furu et al., 2021), og muligens flere kvinner innenfor idrett og trening (Engseth et al., 2022). Om HP påvirker prestasjonen negativt eller positivt hos kvinner som bruker det er enda usikkert (Myllyaho et al., 2021; Riechman & Lee, 2022) uten tilstrekkelig forskning på dette er det vanskelig å si om HP har en innvirkning på muskelvekst, styrke og styrketrening hos kvinnelige fritidsstyrkeutøver. Derfor er det nødvendig at det blir gjort mer eksperimentell idrettsforskning av høy kvalitet for å se om det er forskjeller i styrke og muskelvekst-tilpasninger hos kvinnelige fritidsstyrkeutøvere.

Hensikten med prosjektet

Målet med denne studien er å undersøke om det er forskjell i overkroppsstyrke og muskelmasse, etter 8 uker systematisk styrketrening, mellom hormonell prevensjon bruk, og ikke hormonell prevensjon bruk hos kvinnelige fritidsstyrkeutøvere.

Hva prosjektet går ut på

I dette studiet skal vi se nærmere på om HP påvirker muskelvekst, muskelstyrke og styrketrening i overkroppen hos kvinnelige fritidsstyrkeutøvere. Vi trenger derfor deltaker som skal være med i intervensjonsgruppen (HP bruk) og deltakere som kan være med i kontrollgruppen (ikke HP bruk). Studien vil foregå over en 8 ukers treningsperiode. De 8 ukene vil bestå av egentrening hvor du skal følge et spesifikt treningsprogram. Det vil også bli gjort en pre-test i starten, en follow-up-test etter 4 uker og en post-test etter 8 uker når treningsperioden er ferdig. Testing, innføring i treningsprogrammet, øvelsene, teknikk, intensitet og belastning vil skje samme uken som pre-testingen. Når treningsperioden er ferdig og de siste testene er gjort vil dette kunne være med på si noe om HP eventuelt påvirker muskelvekst, styrke og styrketrening hos kvinnelige fritidsstyrkeutøvere. I tillegg vil det også være en viktig bidragsyter for kvinnehelse og kvinners representasjon i idrett og treningsvitenskapen.



Hvem ser vi etter?

Vi ser etter godt trente og motiverte unge kvinner som driver med styrketrening og enten bruker eller ikke bruker HP.

Inklusjonskriterier:

- Ha trent styrke i minst et år
- Ha hatt en treningsfrekvens på minst 3 økter i uken de siste 6mnd
- Være skadefri de siste 4 ukene.
- Være mellom 18 – 40 år
- Klare 0,5 x kroppsvekt i benkpress eller brystpress
- Dopingfri

Testing vil foregå i Tromsø. Det vil derfor være avgjørende for din deltakelse at du er i Tromsø i de forskjellige tidsperiodene.

Treningsprogrammet og rapportering

Treningsprogrammet vil bestå av 2 overkroppsøkter i uken. Du står fritt til å trene underkropp som du vil i løpet av treningsperioden, men du kan ikke trene mer overkropp en hva som er oppgitt i programmet.

Økt 1				
Øvelser:	Sett x reps	RIR	Pause	Dato:
Skrå benkpress m/hantler	4 x 8-10		2-3 min	
Nedtrekk m/nøytralt grep	4 x 8-10		2-3 min	
Flyes i flatbenk	3 x 8-10		2-3 min	
Roing m/hantel	3 x 8-10		2-3 min	
Sidehev m/hantler	4 x 10-12		2-3 min	
Bicepscurl i kabel	3 x 10-12		2-3 min	

Økt 2				
Øvelser	Sett x reps	RIR	Pause	Dato:
Flatbenk m/hantler	4 x 6-8		2-3 min	
Sittende roing i kabel (smalt grep)	4 x 8-10		2-3 min	
Flyes i skråbenk	3 x 8-10		2-3 min	
Nedtrekk m/smalt grep	3 x 8-10		2-3 min	
Skulderpress m/hantler	4 x 8-10		2-3 min	
Triceps press i kabel	3 x 10-12		2-3 min	

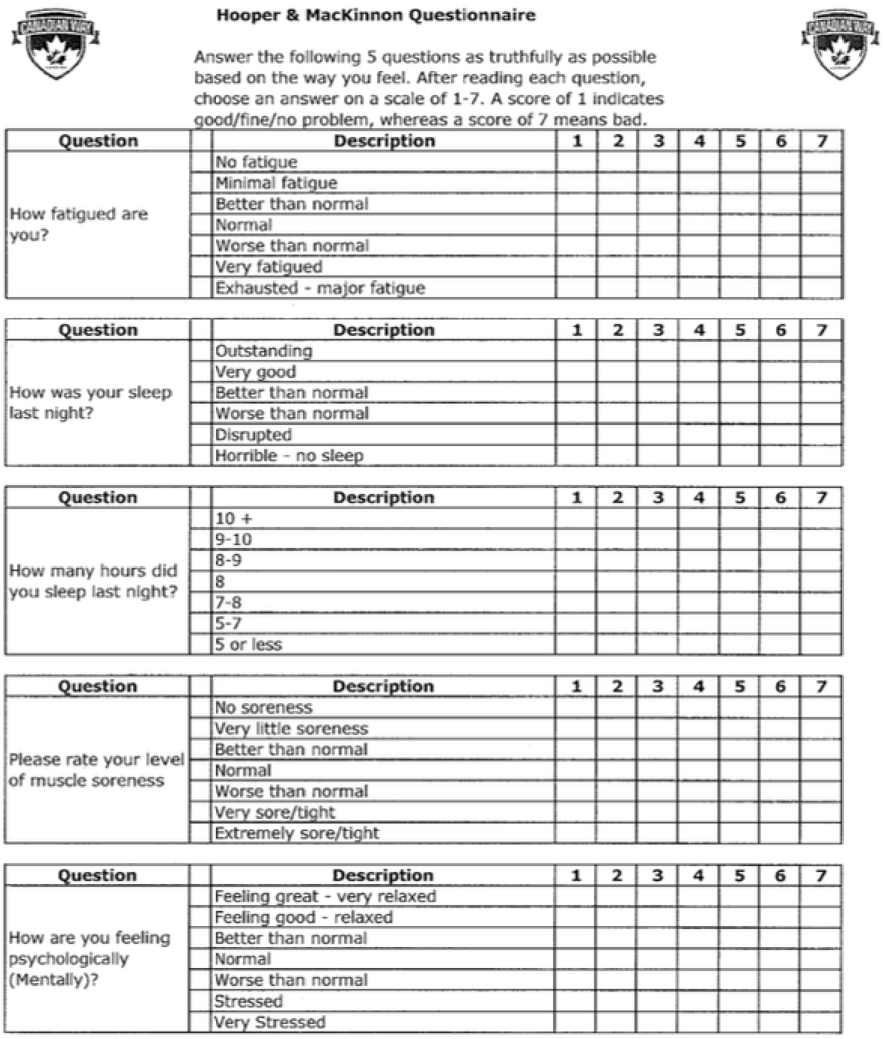
Når du klarer maks antall reps som er satt opp i programmet på alle settene kan du øke med 2,5kg i øvelsen til neste økt. Alle arbeidssett skal gjøres til utmattelse eller nær utmattelse. Det vil si at du kun skal ha 0-2 repetisjoner i reserve (RIR) når du er ferdig. Dette vil være med på å stimulere mest mulig muskelvekst. Programmet er lagt opp slik at man skal progressivt overbelaste muskelen for vær økt. Man gjør dette ved å enten øke i antall repetisjoner eller i kg man løfter for hver økt. Det oppfordres til å øke i vekt på øvelsene, selv om det kan føre til at man ikke klarer alle repetisjonene.

Oppfølging og rapportering av trening

Det er også viktig at alle øktene logges og sendes inn hver uke, du vil også da kunne stille spørsmål og få tilbakemeldinger på treningen. Når du har gjennomført en uke med trening (2/2 økter) sender du inn planen med loggingen av øktene, samt video av siste settet på den siste øvelsen. Dette skal gjøres hver uke. Du vil få tilgang til treningsprogrammet gjennom Microsoft Excel eller Google sheet, slik at du har mulighet til å loggføre alle øktene. Det kreves også at man gjennomfører minst 80% (13/16 økter) av alle øktene, hvis ikke vil man bli ekskludert. Men det beste er at man gjennomføre alle 16 øktene i løpet av de 8 ukene.

Hooper & Mackinnon Questionnaire

Hooper & Mackinnon Questionnaire er et spørreskjema som dere skal fylle ut å sende inn hver uke med treningsplanen. Spørreskjemaet består av 5 spørsmål som du skal svare på ved hjelp av en skala fra 1-7. Spørreskjemaet skal fylles ut etter hver økt. Spørreskjemaet vil bli oversatt til norsk og gjort om til Word-format slik at det kan fylles ut og sendes inn.



Hooper & MacKinnon Questionnaire

Answer the following 5 questions as truthfully as possible based on the way you feel. After reading each question, choose an answer on a scale of 1-7. A score of 1 indicates good/fine/no problem, whereas a score of 7 means bad.

Question		Description	1	2	3	4	5	6	7
How fatigued are you?		No fatigue							
		Minimal fatigue							
		Better than normal							
		Normal							
		Worse than normal							
		Very fatigued							
		Exhausted - major fatigue							

Question		Description	1	2	3	4	5	6	7
How was your sleep last night?		Outstanding							
		Very good							
		Better than normal							
		Worse than normal							
		Disrupted							
		Horrible - no sleep							

Question		Description	1	2	3	4	5	6	7
How many hours did you sleep last night?		10 +							
		9-10							
		8-9							
		8							
		7-8							
		5-7							
		5 or less							

Question		Description	1	2	3	4	5	6	7
Please rate your level of muscle soreness		No soreness							
		Very little soreness							
		Better than normal							
		Normal							
		Worse than normal							
		Very sore/tight							
		Extremely sore/tight							

Question		Description	1	2	3	4	5	6	7
How are you feeling psychologically (Mentally)?		Feeling great - very relaxed							
		Feeling good - relaxed							
		Better than normal							
		Normal							
		Worse than normal							
		Stressed							
		Very Stressed							

Fysiske tester og spørreskjema

Det vil bli gjort måling av kroppssammensetning og testing av styrke før, under og etter treningsperioden for å kunne se om hormonell prevensjon utgjør noen forskjell i utviklingen av muskelvekst og styrke. Testingen vil foregå på styrkelaben til idrettshøgskolen ved Alfheim/Romssa Arena. Testingen vil bli gjennomført i uke 40, alle deltakere vil bli kontaktet for booking av styrketest og måling av kroppssammensetning.

Dexa – scan:

Dexa-scanen vil vise oss kroppssammensetningen din, dvs; hvor mye fettfri masse du har på kroppen, beintykkelse og fettprosent. Den vil kunne gi oss et tydelig svar på hvor mye muskler du har klart å bygge etter 8 uker. Dexa-scanen MÅ gjøres på tom mage for å få en tydelig og nøyaktig måling. Så det betyr ingen mat eller drikke før, da dette kan gi utslag på målingene, det vil derfor bli gjort tidlig om morgenen (07.00-12.00). Hvis det ikke lar seg gjøre å møte opp på helt tom mage er det viktig at du noterer ned hvor mye du har drukket og spist (dl & g).

3RM styrketest:

Det vil bli gjennomført 3 repetisjoner maksimal i benkpress i smithmaskin og seal row. Det vil si at du skal løfte så mye vekt du klarer for 3 repetisjoner i øvelsene. Vi gjør dette for å kunne se om den styrken din har endret seg i løpet av treningsperioden. Testingen vil foregå på styrkelaben til idrettshøgskolen ved Alfheim/Romssa arena med fagpersoner og prosjektansvarlig til stede etter gejnnomført DEXA-scan. Det vil derfor være lurt å ha med drikke å mat slik at du ikke må gjøre styrketestene på tom mage.

Greps test:

Du skal klemme så hardt du klarer på en håndklype i 3 sekunder, 2 ganger med den armen du anser som sterkest. Testen vil gjøres under oppsyn og med veiledning fra prosjektleder.

Eggløsningstest:

For å kunne kartlegge menstruasjonssyklusen til deltaker som ikke benytter seg av HP vil det bli gjennomført eggløsningstester. Idrettshøgskolen vil stille med tester.

The low energy availbility in females questionnaire (LEAF-Q)

LEAF-Q er et spørreskjema som skal fange opp fysiologiske symptomer ved utilstrekkelig energiinntak. Spørreskjemaet er kategorisert i 3 deler; skader, gastrointestinal funksjon og menstruasjonsfunksjon og bruk av prevensjonsmidler. Skjemaet er lage for å kunne fange opp symptomer på «den kvinnelige utøvertriaden» (female athlete traid) (Maria & Juzwiak, 2021). Den kvinnelige utøvertriaden er en tilstand som kan oppstå når kvinner trener mye og får i seg for lite næring/energi og da står i fare for å utvikle menstruasjonsforstyrrelser, beinskjørhet dårlig helse, forstyret spiseatferd eller spiseforstyrrelser (Nazem & Ackerman, 2012).

Skjemaet skal fylles ut i starten av studien under pre-test.

Pittsburgh sleep quality index (PSQI)

PSQI er et selvrapporterings skjema som er med på å kartlegge søvnkvalitet og søvnhyggene 1 måned bak i tid. Skjemaet består av 10 spørsmål og tar 5-10 minutter å fylle ut.

Skjemaet skal fylles ut under pre og post-test.

Hva forventes av deg som deltaker?

Som deltaker er det noen ting vi vil oppfordre deg til slik at resultatet skal bli så nøyaktig og bra som mulig. Det innebærer å spise bra, hvile nok, prioritere søvn og følge treningsprogrammet.

Kosthold: Du blir ikke nødt til å følge noen mat plan eller liknende i treningsperioden, men vi vil oppfordre deg til å spise godt for å kunne prestere best mulig. 20-30g protein til hvert måltid eller legge deg på ca 1,6-2,2g protein pr.kg kroppsvekt vil være anbefalt. Det vil heller ikke være gunstig å ligge i kaloriunderskudd under treningsperioden, da det vil gjøre det vanskeligere å bygge muskler.

Søvn og hvile: Nok søvn og hvile vil være viktig for at treningen skal kunne gi best mulig resultater. 8 timer søvn er noe vi vil anbefale å strekke seg etter hver natt. Vil også anbefale å legge opp treningsdagen slik at du møter opp uthvilt til øktene.

Skadefri: For at du skal kunne gjennomføre programmet og være med på studien er det viktig at du holder deg skadefri. Så ikke gjør noe dumt på trening eller hjemme slik at du kan skade deg.

Treningsprogrammet: Det er viktig at du følger treningsprogrammet til punkt og prikke. Ingen dropset, superset eller alternative varianter av øvelsene som er satt opp i programmet. Du skal gjøre det akkurat sånn det er satt opp i programmet. Men du står fritt til å kunne trene så mye bein eller annen type aktivitet som ikke involverer overkroppsstyrketrening.

Takk for din deltakelse!

Har du flere spørsmål ta kontakt på:
ppe040@uit.no; Prosjektleder og masterstudent

ipo011@post.uit.no; Datainnsamler og bachelorstudent

vkv010@post.uit.no; Datainnsamler og bachelorstudent

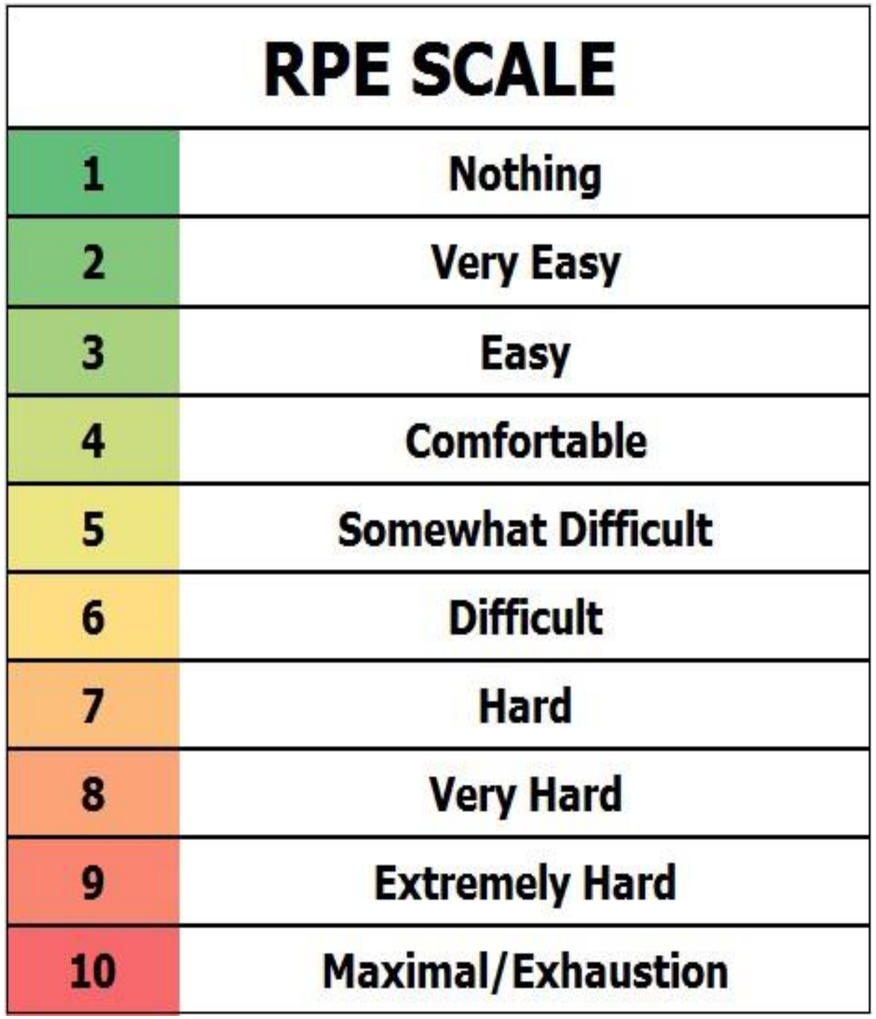
Appendix 5 – Training, sleep and recovery sheet

Uke 40	02.010.2023	03.010.2023	04.010.2023	05.010.2023	06.010.2023	07.010.2023	08.010.2023
Spørreskjema (0 = veldig bra; 7 = veldig dårlig)	**Mandag**	**Tirsdag**	**Onsdag**	**Torsdag**	**Fredag**	**Lørdag**	**Søndag**
Restitusjon *(0 = veldig dårlig; 10 = veldig energisk)*	0-10						
Søvnkvalitet	0-7						
Stress	0-7						
Trøtthet	0-7						
Muskelsårhet	0-7						
Menses/blødning (ja/nei)	Ja/Nei						

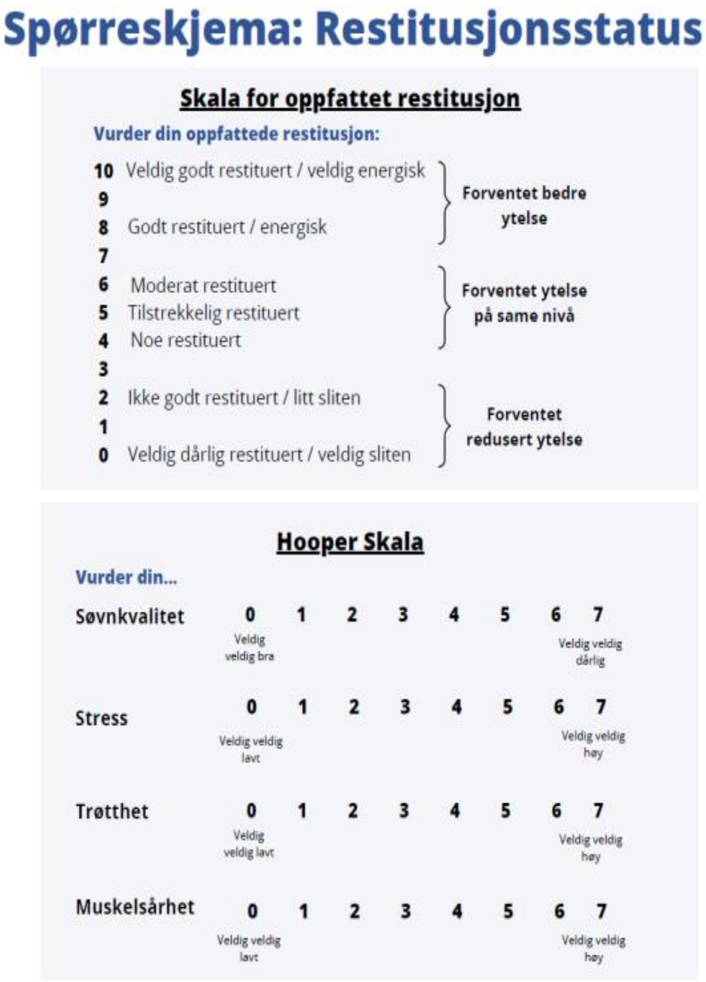
Søvn	**Mandag**	**Tirsdag**	**Onsdag**	**Torsdag**	**Fredag**	**Lørdag**	**Søndag**
Hvordan har du fungert på dagtid? 1=veldig bra, 2=bra, 3=middels, 4= dårlig, 5=veldig dårlig	1-5.						
Har du tatt en/flere blunder i løpet av dagen? Hvor lenge?	Ja/Nei/Tid						
Når gikk du til sengs? kl.	Eks. 22.40						
Når skrudde du av lyset/mobilen? kl.	Eks 22.50						
Når våknet du?	Eks. 07.40						
Hvordan var siste natts søvn totalt sett: 1 = veldig lett, 2= lett, 3 = middels, 4 = dyp, 5 = veldig dyp.	1-5.						

Treningsuken	**Mandag**	**Tirsdag**	**Onsdag**	**Torsdag**	**Fredag**	**Lørdag**	**Søndag**
Forskerprosject Overkropps økter (min og RPE)		85 min, RPE 9			70 min, rpe 8		
Annen type trening (type/varighet)	Løpe, 50min (10km)		Underkropp	Håndball, 80 min		Underkropp	
Intensitet (RPE og/eller bpm)	150 bpm		RPE 8	170 bpm		RPE 9	

				Uke 1	Uke 1
Øvelser:	Sett x reps	Pause	Opplevd anstrengelse (RPE)	Reps pr sett	Vekt pr sett
Skrå benkpress m/hantler	4 x 8-10	2-3 min	RPE 8	10/10/10/8	12kg
Nedtrekk m/ nøytralt grep (nøytral bredt)	4 x 8-10	2-3 min	RPE 8	10/10/8/8	40kg
Flyes i flatbenk	3 x 8-10	2-3 min	RPE 10	10/10/8/	6kg
Roing m/hantler	3 x 8-10	2-3 min	RPE 9	10/10/8/	10kg
Sidehev m/hantler	4 x 10-15	2-3 min	RPE 8	15/13/11/8	5kg
Bicepscurl i kabel	3 x 10-12	2-3 min	RPE 10	12/12/10/	15kg
Økt 2 Dato:				Uke 1	Uke 1
Øvelser:	Sett x reps	Pause	Opplevd anstrengelse (RPE)	Reps pr sett	Vekt pr sett
Benkpress m/hantler	4 x 6-8	2-3 min	RPE 8	8/8/7/6	12kg
Sittende roing i kabel (smalt grep)	4 x 8-10	2-3 min	RPE 10	10/10/9/8	25kg
Flyes i skråbenk	3 x 8-10	2-3 min	RPE 9	10/9/8/	6kg
Skidrag i kabel	3 x 8-10	2-3 min	RPE 9	10/9/9/	30kg
Skulderpress m/hantler	4 x 8-10	2-3 min	RPE 8	10/10/9/8	14kg
Tricepspress i kable	3 x 10-12	2-3 min	RPE 10	12/12/8/	35kg



RPE SCALE	
1	Nothing
2	Very Easy
3	Easy
4	Comfortable
5	Somewhat Difficult
6	Difficult
7	Hard
8	Very Hard
9	Extremely Hard
10	Maximal/Exhaustion



Spørreskjema: Restitusjonsstatus

Skala for oppfattet restitusjon

Vurder din oppfattede restitusjon:

10	Veldig godt restituert / veldig energisk	**Forventet bedre ytelse**
9		
8	Godt restituert / energisk	
7		
6	Moderat restituert	**Forventet ytelse på same nivå**
5	Tilstrekkelig restituert	
4	Noe restituert	
3		
2	Ikke godt restituert / litt sliten	**Forventet redusert ytelse**
1		
0	Veldig dårlig restituert / veldig sliten	

Hooper Skala

Vurder din...

Søvnkvalitet	**0** Veldig veldig bra	**1**	**2**	**3**	**4**	**5**	**6**	**7** Veldig veldig dårlig
Stress	**0** Veldig veldig lavt	**1**	**2**	**3**	**4**	**5**	**6**	**7** Veldig veldig høy
Trøtthet	**0** Veldig veldig lavt	**1**	**2**	**3**	**4**	**5**	**6**	**7** Veldig veldig høy
Muskelsårhet	**0** Veldig veldig lavt	**1**	**2**	**3**	**4**	**5**	**6**	**7** Veldig veldig høy