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Pseudomyopia and nearwork-induced transient myopia (NITM) in young Norwegian adults

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This thesis is worth 30 study points

Summary

Purpose:

In 2007, the smartphones as we know them today entered the market. The introduction of this digital unit has had a significant impact on our mass media habits and has caused an increase in time spent conducting near work. As near work increases the accommodative response, causing NITM, it is known that excessive viewing time at near can affect the refractive measurements at far. The aim of this study is to investigate the incidence of pseudomyopia and NITM in young healthy myopic Norwegian adults by different noncycloplegic and cycloplegic measurements, and its possible association to recent years change in mass media habits.

Method:

In order to achieve data of habitual and fully relaxed refractive status, measurements of noncycloplegic autorefraction, subjective refraction, retinoscopy and cycloplegic autorefraction were performed and compared on 44 healthy young myopic adults who owe a smartphone. A questionnaire primarily about the participants' use of digital units was also filled out. The age range was 18 to 40 years (mean 29.6 ± 4.7 years).

Results:

When comparing the mean spherical equivalent (SE) of the noncycloplegic autorefraction with (1) the cycloplegic autorefraction and (2) the subjective refraction, the noncycloplegic autorefractor yields more negative values: (1) -0.433 ± 0.372 D; p=0.000; (2) -0.206 ± 0.309 D; p=0.000 respectively. The mean SE of subjective refraction also yields more negative value than the cycloplegic autorefraction: -0.228 ± 0.406 D; p=0.000. Comparison of the mean SE of cycloplegic autorefraction and the retinoscopy presents no significant difference in value: -0.021 ± 0.323 D; p=0.678. 40% of the participants have a noncycloplegic autorefraction value which is more negative equal to 0.50D or more compared to the cycloplegic autorefraction. Within the same measurement comparison, 24.4% have a negative value of more than 0.50D. Participants with a low accommodative lag of 0.50D or less (5) measured with the cross-cylinder test, had a significantly higher mean difference in SE between noncycloplegic and cycloplegic autorefractions than participants with a higher accommodative lag (6): (5) -0.642 ± 0.375 D; (6) -0.317 ± 0.322; p=0.05.

Conclusion:

The present results confirm that noncycloplegic autorefraction yields more negative values than subjective refraction, cycloplegic autorefraction and retinoscopy. There are significant differences between the refractive values of all methods ($p < 0.05$) except the cycloplegic autorefraction and the noncycloplegic retinoscopy. There was an incidence of 7% pseudomyopia among the participant when comparing the cycloplegic autorefraction with the noncycloplegic subjective refraction (difference > 0.50 D), where 4.5 % would not have been detected without cycloplegic refraction. No significant association between the use of digital units or smartphones and pseudomyopia and NITM was found in this sample of young myopic adults. A larger sample is recommended to confirm these results.

Key words: myopia, pseudomyopia, NITM, autorefraction, cycloplegia, refraction, retinoscopy, digital units, smartphones

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Sammendrag

Hensikt:

I 2007 entret smarttelefonene slik vi kjenner de i dag markedet. Introduksjonen av denne digitale enheten har hatt en signifikant innvirkning på våre medievaner og har forårsaket en økning i antall timer vi bruker øynene på nært. Denne type nærarbeid gir økt akkomodasjon og forårsaker nærarbeidsindusert forbigående myopi (NIFM) som kan påvirke refraksjonsutmålingen på avstand. Hensikten med forskningen er å undersøke forekomsten av falsk nærsynthet og NIFM hos unge, friske, voksne myope nordmenn ved å utføre ulike ikke-cykloplegiske og cykloplegiske målinger, og om eventuelle funn kan assosieres til de senere års endrede medievaner.

Metode:

For å kunne vurdere refraktive data av øyets normale tilstand og helt avslappet tilstand, ble ikke-cykloplegisk autorefraktormåling, subjektiv refraksjon, retinoskopi og cykloplegisk autorefraktormåling utført og sammenlignet på 44 unge, friske voksne myope som eier en smarttelefon. Et spørreskjema med spørsmål primært om deltagerens bruk av digitale enheter ble også fylt ut. Deltagerne var fra 18 til 40 år gamle (gj.snitt 29.6 ± 4.7 år).

Resultat:

Sfærisk ekvivalent (SE) av den ikke-cyckloplegiske autorefraktormålingen er mest negativ sammenlignet med (1) SE av cykloplegisk autorefraktormåling og (2) SE av subjektiv refraksjon: (1) -0.43 ± 0.37 D; $p = 0.000$; (2) -0.21 ± 0.309 D; $p = 0.000$. SE av den subjektive refraksjonen er også mer negativ enn den cykloplegiske autorefraktormålingen: -0.22 ± 0.41 D; $p=0.000$. Ved sammenligning av SE cykloplegisk autorefraksjon og SE retinoskopi er det ingen signifikant forskjell i verdi: -0.02 ± 0.33 D; $p = 0.290$. 37.2 % av deltagerne har en ikke-cykloplegisk autorefraktorverdi som er ≥ 0.50 D mer negative sammenlignet med den cykloplegiske autorefraktorverdien. 23.3 % har > 0.50 D mer negativ ikke-cykloplegisk autorefraktorverdi innenfor samme sammenligning. Deltagere med akkomodasjon ≤ 0.50 D (3) målt med krysskort på 40cm, hadde en signifikant større forskjell mellom ikke-cykloplegisk og cykloplegisk autorefraktormåling enn deltagerne med akkomodasjon > 0.50 D (4): (3) -0.64 ± 0.39 D; (4) -0.32 ± 0.32; $p < 0.05$.

Konklusjon:

Forskningsprosjektet bekrefter at ikke-cykloplegiske autorefraktormålinger er mer negative i verdi enn subjektiv refraksjon, retinoskopi og cykloplegisk autorefraktormåling. Det er signifikante forskjeller i de refraktive verdiene mellom alle målemetodene ($p < 0.05$) bortsett fra når cykloplegisk autorefraktormåling og retinoskopi sammenlignes. Det ble funnet 7 % pseudomyopi (forskjell > 0.50 D) blant deltagerne når cykloplegisk autorefraktorverdi og subjektiv refraksjon sammenlignet, 4.5 % ville ikke ha blitt oppdaget uten cykloplegisk refraksjon. Det ble ikke funnet signifikant assosiasjon mellom bruk av digitale enheter eller smarttelefoner og pseudomyopi og NIFM i dette utvalget av unge, myope voksne. Et større utvalg er anbefalt for å kunne bekrefte dette resultatet.

Nøkkelord: myopi, pseudomyopi, NIFM, autorefraktor, cykloplegi, refraksjon, retinoskopi, digitale enheter, smarttelefoner

Abbreviations

MH = Mari Hovland

NITM = nearwork-induced transient myopia

NIFM = nærarbeidsindusert forbigående myopi

VA = visual acuity

D = dioptre

RG test = duochromatic test (red/green test)

SER = spherical equivalent refractive (error)

SE = spherical equivalent

RE = right eye

LE = left eye

N auto = noncycloplegic autorefraction

N subj = noncycloplegic subjective refraction

N ret = noncycloplegic retinoscopy

C auto = cycloplegic autorefraction

PRA = positive relative accommodation

NRA = negative relative accommodation

EOM = early onset myopia

LOM = late onset myopia

SD = standard deviation

REK = Regionale Komitteer for Medisinsk og Helsefaglig Forskningsetikk

NSD = Norsk Senter for Forskningsdata

Definitions

Emmetropia: -0.50 D < SER < + 0.50 D

Mild myopia: -0.50 D ≥ SER > -3.00 D

Moderate myopia: -3.00 D ≥ SER > -6.00 D

Severe myopia: SER ≤ -6,00 D

Early onset myopia (EOM): < 15 years

Late onset myopia (LOM): ≥ 15 years

Gold standard of refraction: Cycloplegic autorefraction

Pseudomyopia: >0.50 D of negative value than the gold standard

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Mari Hovland

1 Introduction

1.1 Background

Myopia is on the rise worldwide as reported by several published studies the recent years (Breslin, O'Donoghue, & Saunders, 2013; Lam, Lam, Cheng, & Chan, 2012; Wang et al., 2020; Zhou et al., 2016), causing a global concern of visual impairment and sight-threatening ocular complications (Verhoeven et al., 2015). Risk factors for myopia has been discussed and investigated for many decades, and there are still many unanswered questions. The aetiology of myopia is still unclear with inconsistent findings in different studies. Environmental factors seem to play a crucial role, but the effect of gene-environment interaction on the aetiology is still controversial and inconsistent (Pan, Ramamurthy, & Saw, 2012). Higher educational achievements in parents and children are found to be important determinants of myopia (O'Donoghue et al., 2015), but higher education seems to be an additive rather than explanatory factor (Williams et al., 2015). In a global perspective, there appears to be a strong correlation between myopia and genetic factors, ethnicity, urban environment and time spent outdoors (Guggenheim et al., 2012; O'Donoghue et al., 2015; Rudnicka et al., 2016). How to prevent myopia progression or myopia onset has also been a key question within myopia research. Several studies have indicated that outdoor activity is a strong inhibitor for development of myopia. A study comparing prevalence of myopia between students of Chinese ethnicity living in Singapore and Sydney (Rose et al., 2008), suggested that the higher prevalence of myopia in Singapore was due to an earlier educational pressure and notably less time spent outdoors (3,05 hours per week vs 13,75 hours per week in Sidney). A review and meta-analysis of the global prevalence of myopia in childhood and adolescence (Rudnicka et al., 2016) showed that the prevalence is much higher in East-Asia than e.g. in the Caucasian population, with an estimated prevalence of 80% myopia in East-Asia versus 23% amongst Caucasian by the age of 18, and with twice as many myopic females as males in both Caucasian and East-Asian by the age of 18 years. A recent school-based study in East-China revealed 92.7% myopia amongst 18 year old students (Wang et al., 2020). A study in Norway confirmed that the myopia prevalence amongst Norwegian adolescent is low compared to e.g. the prevalence in East-Asia. Only 16% of the Caucasian (Northern European) participants between 17 and 19 years of age were myopic, despite the low levels of daylight hours in the autumn-winter season and high levels of indoor-activity and near work (Hagen et al., 2018). This research did not find association between time spent on near work or time spent on outdoor activities and myopia. Doubt about the association between near work and myopia had also been raised by research of adolescents in rural China (Lu et al., 2009). In Australian school children they found a significantly independent association between close reading and continuous reading and myopia, but not with time spent on near work. This may indicate that the intensity rather than the total duration of near work is an important factor (Ip et al., 2008). The results of the Norwegian study of myopic adolescent led to further investigation of cone photoreceptors that are thought to play a role in susceptibility to myopia development. Differences in cones sensitive to light of long and medium wavelengths have been found between individuals and ethnicities. The genetic composition of these cones in Norwegian adolescent may partly explain the low prevalence of myopia and why females are more susceptible to myopia development (Hagen et al., 2019).

1.2 Pseudomyopia and NITM

Although the correlation of near work and development of myopia and progression still seem inconclusive, extensive near work is a well-known risk factor for pseudomyopia. Pseudomyopia is a condition where the accommodative system is coherently or intermittently overaccommodating, and therefore inducing a more myopic refraction than the eye actually have. In other words, pseudomyopia can be regarded as an accommodative excess as the accommodation is working excessively. Pseudomyopia, accommodative excess, ciliary spasm, accommodative spasm and spasm of the near-reflex are all terms that have been used interchangeably as there are some confusion and disagreement in the literature (Scheiman & Wick, 2002, p. 349).

Nearwork-induced transient myopia (NITM) refers to the small and transient myopic shift in the far point of the eye after a period of sustained near work, with it reflecting an accommodative aftereffect. The initial NITM and the decay duration describe the accommodative response following the completion of a sustained near task. The initial NITM is defined as the difference in accommodative response in diopters at far immediately before and after a sustained near task. The decay duration represents the amount of time it takes to return the NITM accommodative response back to the pre-task baseline level. (Z. Lin, Vasudevan, Zhang, et al., 2012). The initial NITM usually ranges from 0.12 D to 0.90 D, with a mean of approximately 0.30 D (Ciuffreda & Vasudevan, 2008; Owens & Wolf-Kelly, 1987). The decay duration ranges from 30 seconds to 1 hour or even more, depending on many factors such as the task duration and accommodative demand, with values of 20-60 seconds normally (Z. Lin, Vasudevan, Zhang, et al., 2012). In a study of 6 and 13 year old

Chinese children, pseudomyopia was not found to be an independent risk factor for myopic progression (Kang et al., 2020).

NITM is in this present study considered as a potential contributor to eventual findings of more negative values in the noncycloplegic versus the cycloplegic measurements. Especially the noncycloplegic autorefractor measurement as this is the first instrument the patient encounter from the waiting area where the smartphone is often used. The use of smartphone will set the eyes in an accommodative state and can cause overminused measurements. In a study of baseline characteristics of NITM in children, the initial NITM magnitude was significantly larger and the decay duration was significantly longer in the myopic children than that observed in age-matched children with either emmetropia or hypermetropia (Z. Lin, Vasudevan, Liang, et al., 2012). According to research of NITM in anisometropia, the more myopic eyes exhibit significantly increased NITM magnitude and larger decay area as compared to the less myopic eyes (Zhong Lin et al., 2013). There has also been found a link between onset of myopia and the amount of additivity (cumulative increase of NITM over time) achieved after an extended period of near work. There was a significant additivity of NITM in the early onset myopes (EOMs) and the late onset myopes (LOMs), but not in the emmetropes (EMMs). The decay of NITM was only significantly prolonged in the EOMs, but the LOMs exhibited a trend in the same direction (Ciuffreda & Lee, 2002; Ciuffreda & Vasudevan, 2008). NITM has been regarded as one of many possible environmentally based, near work contributory factors of myopia development (Vera-Diaz, Strang, & Winn, 2002), but recent research found that NITM was only significantly associated with the progression of a myopic refractive shift among the hyperopes (Z. Lin, Vasudevan, Liang, Zhou, & Ciuffreda, 2020).

As cycloplegia eliminate the ability of the eye to accommodate, the eventual pseudomyopia or NITM will be identified when the value of the noncycloplegic and the cycloplegic refraction are compared. If the noncycloplegic refraction is of a more negative value than the cycloplegic measurement, the difference in value will represent the amount of pseudomyopia found in the subject. Headaches, eye pain, asthenopia, blurred vision, unstable visual acuity, photophobia and esophoria can all be symptoms and signs of pseudomyopia, but also exophoria if the primary disorder is convergence insufficiency and accommodative excess (pseudomyopia) is secondary (Scheiman & Wick, 2002, pp. 350-351).

1.3 Mass media habits

Statistics Norway have carried out annual surveys of the Norwegian population between 9-79 years of age and their use of mass media. The 2019 survey show that the age group 16-34 has the highest average of time spent on internet during 24 hours. In 2005 this group used the internet just above 1 hour a day, in 2019 this had increased to almost 4.5 hours a day. In the age group 16-44, 95 % report using their mobile phone for internet-purposes. In 2009 only 13 % in the same age group reported the same (Statistics Norway, 2020).

Smartphones have existed since the mid-late 1990s, but the first smartphone with finger-operated touchscreen as we know them today was introduced in December 2006. In 2007 Apple Computer launched the first smartphone designed for the masses (Wikipedia, 2020), and the smartphones rapidly became a common asset by popular demand. 95% of Norwegian children between the age of 9-15 have access to a smartphone. Especially within the youngest group (9-12) the increase has been immense, from 1 of 2 children in 2012 to 9 of 10 children in 2018. 78% of Norwegians between 20-44 years of age had access to smartphone in 2012, latest report reads 99% in 2018 (medianorway & Statistics Norway, 2020).

1.4 Refractive methods

The noncycloplegic autorefraction is a standard preliminary measurement in Norwegian optometric practices today which provides a quick and easy objective refractive measurement of sphere, cylinder and axis of the eye. Through both experience and published research, it is well known amongst optometrists that autorefractor measurements vary depending on the accommodative status of the patient, especially in children but also in adults (Fotedar et al., 2007; Hashemi et al., 2016). Therefore, noncycloplegic subjective refraction remains as the gold standard for adult prescribing as autorefractors are only satisfactory for a preliminary refraction (Goss & Grosvenor, 1996). However, these are not the only methods of distance refraction regularly used by Norwegian optometrists. Since 1. May 2004, Norwegian optometrist who meet the educational requirements, have conducted cycloplegic refractions which paralyses the ocular accommodation and uncover the correct ametropia of the eye. In several epidemiological studies of refractive errors, the cycloplegic autorefractor measurement is recommended as the gold standard method of refraction (Fotouhi, Morgan, Iribarren, Khabazkhoob, & Hashemi, 2012; Morgan, Iribarren, Fotouhi, & Grzybowski, 2015). In Norwegian optometric practices cycloplegic refractions is generally done on the adult population on indication, but always recommended on children due to their wider accommodative range. A study carried out on Australian schoolchildren, showed that cycloplegic refraction was particularly important in children up to the age of 12 (Fotedar et al., 2007).

There have been several studies comparing various methods of refraction and exploring the necessity of cycloplegic refraction. Jorge et al. compared noncycloplegic methods on healthy young adults aged 18-34, and found that retinoscopy was a more accurate starting point for noncycloplegic subjective refraction than autorefractor (Jorge, Queiros, Almeida, & Parafita, 2005). In the Tehran Eye Study, refractive data from people aged 9 to 95 years showed that noncycloplegic autorefraction overestimated myopia and underestimated hyperopia. Overestimation of myopia was highest in the 21-30 and 31-40 year groups. When these data were compared to subjective refraction, they found subjective refractions to be reliable in myopes of all ages as the results were comparable with those by cycloplegic refraction. It was concluded that cycloplegia may not be crucial in some cases if the only important outcome measure is prevalence of myopia, but cycloplegic refraction should be considered as the gold standard for epidemiological studies of refraction up to the age of 50 (Fotouhi et al., 2012; Hashemi et al., 2016; Morgan et al., 2015).
In contrast, the Twins Eye Study in Tasmania (TEST) and the Brisbane Adolescent Twin Study concluded that noncycloplegic autorefraction could result in measurements of greater myopia than cycloplegic autorefraction in teenagers (13-19 years of age) but not in adults 20-26 years. By this suggesting that cycloplegia is not required in population estimates of refractive error for adults after the age of 20 years (Sanfilippo et al., 2014). This was partly confirmed by Mimouni et al. in their comparison of noncycloplegic and cycloplegic SER of enlisted soldiers aged 18-21. As latent hypermetropia of +1 to +2 D were found in the hypermetropic young adults, but only pseudomyopia of -0.50 D in the myopic, they concluded that cycloplegic refraction should be performed in young hypermetropic adults complaining of asthenopia (Mimouni et al., 2016). The Anyang University Students Eye Study (AUSES) found higher mean differences in hyperopes and emmetropes than in myopes: 1.80±1.11D, 1.26±0.93D and 0.69±0.69D, respectively, when comparing noncycloplegic and cycloplegic autorefraction. In contrary to the two prior studies of similar age-group, AUSES recommend cycloplegic refractions on all in this age-group (mean age 20.2 ± 1.5 years) to avoid significant misclassification of myopia, emmetropia and hyperopia (Sun et al., 2018). There seem to exist some disagreement concerning the necessity of cycloplegic

measurements in adults. The various results may be due to different cycloplegic regimes and different ethnicities.

Retinoscopy is a method to objectively determine the refractive error of the eye and can be done both noncycloplegic and cycloplegic. Before autorefractors became standard equipment in optometric practices, static retinoscopy was the preliminary refraction optometrists performed before proceeding to the subjective refraction. Today it seems like the autorefractor has replaced the use of retinoscopy for many optometrists.

The present study will hopefully give clinical relevant insights into the four methods of refraction addressed here, and their expected values in the adult myopic population between 18 and 40 years old and whether media habits impact refraction measurements. It will also provide valuable statistics of the incidence of pseudomyopia which can be used to assess the need for cycloplegic refraction in this particular population.

2 Motivation and aim of the study

As an experienced optometrist, the impression is that the encounters of pseudomyopic patients are increasing. This impression is based on standard noncycloplegic optometric measurements performed in a standard Norwegian optometric practice.
The cause of this can be multifactorial and the curiosity regarding these possible reasons is a motivation for conducting this study. There exists no clinical statistics that can confirm more encounters of pseudomyopia, and there is a possibility that the encounters can be explained by the optometrist gaining more experience and the modification of procedures through the years. The optometrist has been working actively as an optometrist since 2004. Within the timespan 2004-2020 the mass media habits have changed significantly. Is the impression of more pseudomyopic patients somehow related to this change in mass media habits and more time spent looking at near, or are there other reasons? As myopia is an increasingly health concern in a global perspective, all research that can give more information about how myopia adopts to environmental changes is of importance and interest.

Aim of the study

The aim of the study was to investigate the incidence of pseudomyopia and nearwork-induced transient myopia (NITM) in young Norwegian adults with standard clinical and diagnostic equipment for refraction measurements, and whether it was associated with the extensive use of digital units. A sub aim was also to investigate the need of cycloplegic refractions in Norwegian myopic adults.

3 Methods

3.1 Study population and recruitment Study population

3.1.1 Study population

A cross-sectional study was carried out in an optometric practice during the recruitment period, on patients who met the inclusion criteria and consented to participation. Qualified to participate were myopic Caucasian males and females between 18 and 40 years of age, without ocular disease and in general good health. All measurements were conducted by one experienced optometrist (MH).

Inclusion criteria

1. Spherical equivalent subjective refractive error of -0.50 D or less.
2. Best corrected VA of Snellen ≥ 1.0.
3. Age 18-40.
4. Caucasian male and female.
5. Own a smartphone.

Exclusion criteria

1. Decompensating horizontal and vertical phorias, tropia and suppression.
2. History of ocular disease, trauma or injury that could influence the refractive error of the eye.
3. Systemic diseases known to affect the visual system.
4. Medication with side-effects on the visual system.
5. Subjects who have undergone refractive surgery or other type of surgery that influenced refractive error.
6. A narrow anterior chamber angle (≤ 2) graded by the van Herick method.

3.1.2 Recruitment

Recruitment of subjects took place in the optometric practice of Brilleland Grønland in Oslo, Norway, in the period between 5. October 2019 and 10. July 2020. Patients who met the criteria, would on completion of their routine eye examination be invited to participate in the study. The goal was 100 participants. Due to Covid19 restrictions and partial redundancy for the optometrist, no participants were recruited in the period between 16. March 2020 and 27. April 2020.

The patient was first given oral information about the study. If the patient wanted to participate, written information about the study was given the patient in the format of a consent form (Annex 1). Informed consent was obtained by all participants prior to inclusion in the study. The consent

was signed both by the subject and the optometrist conducting the study. In most cases the subjects came back to the practice another day for a cycloplegic autorefraction measurement. The participants were also given a questionnaire (Annex 2), mainly with questions about their myopia and the use of smartphone and other digital units.
Recruited patient's customer number was replaced with a unique identification number to ensure anonymity of the participants. The decoding list was kept separately from the data collection sheets and will be deleted on the date set by the Regional Committees for medical and health research ethics (REK). The participant can at any time disengage themselves from the study without any further explanation.

Participants

50 patients who initially met the criteria were recruited to this study, 79,5 % of them on their routine eye examination for contact lenses or contact lens fitting. The rest wore glasses only. To achieve cycloplegic measurements, 79,5 % of the participants had to come back for a second appointment within 30 days of the first examination. As there are different occurrence of myopia in different ethnicities (Rudnicka et al., 2016), only Caucasian patients were recruited to this study of pseudomyopia and nearwork-induced transient myopia (NITM) in myopic adults.
After collecting the data, 3 participants revealed additional information about their health that led to exclusion from the study. 1 participant was emmetropic according to cycloplegic measurement and therefore excluded. 2 participants with severe myopia (<-8.00 D) were also excluded as their data were atypical compared to the other participants. Removal of these 6 participants had no overall effect on the results, but the severe myopia group was left with only 1 participant. The age of the final 44 participants ranged from 18.3 to 39.7 years, with a mean age of 29.6 ± 4.7 years. Age was based on the day of their first visit. 38.6% of the participants were males.

3.2 Measurements

Measurements required for the study was a part of the patient's routine examination by one experienced optometrist (MH). Cycloplegic measurements were in most cases not achievable within the timeframe of the routine examination, or not accepted by the participant that particular day because of the side effects or time requirements. In those cases, a second examination was agreed upon and completed within 30 days of the first examination. The patients also had to complete a questionnaire (Annex 2), mainly with questions about their myopia and digital habits. The routine examination included medical, ocular and family history, and a set of standard optometric measurements that was performed on both eyes. The standard measurements included: noncycloplegic and cycloplegic autorefraction, noncycloplegic subjective refraction, noncycloplegic retinoscopy, intraocular pressure (IOT), fundus photography, visual acuity (VA), eye-dominance, cover test (CT), Howell phoria cards, motility, pupil distance (PD), pupil function tests, trial frame and trial lenses, ophthalmoscopy, slit-lamp microscopy (it was not possible to obtain all measurements listed on all participants).

The measurements and questions of particularly importance for this study are the following: Noncycloplegic and cycloplegic autorefraction, noncycloplegic subjective refraction, noncycloplegic retinoscopy, time spent on smartphone and/or digital units and myopia onset.

Spherical equivalent refractive errors (SER) are calculated by the formula:

SER = sphere + (cylinder/2).

<u>Noncycloplegic autorefraction (N auto):</u>

The measurements were executed by the Topcon KR-800. 3-6 readings on each eye, always conducted on the right eye (RE) first. The sphere and cylinder were the foundation for the N auto SER value.

<u>Noncycloplegic subjective refraction (N subj):</u>

Performed with the TopCon CV3000 phoropter. RE was measured first. Lowest value of cylindric power was preferred whenever the end result was inconclusive. Duochrome/red-green test (RG test) was done monocularly. If R equal G (R=G) was not obtainable, then R>G was chosen. A VA of Snellen 1,0 was required to meet the inclusion criteria. Same procedure for left eye (LE).

Binocular VA was blurred by adding plus/reducing minus until a maximum of Snellen = 0.8 was achieved. This was verified by testing the visual acuity of the patient. Spherical refraction was adjusted by 0.25 D steps until balance between RE and LE was accomplished. In events of no balance, less blur was granted the dominant eye. Blur was decreased until subjective best correction was obtained with a binocular VA of Snellen = 1.2. Final RG test done binocularly to avoid over-minus. The sphere and cylinder were the foundation for the N subj SER value.

Noncycloplegic retinoscopy (N ret):

Performed with a Keeler Professional Streak Retinoscope at approximately 67cm, with working distance lenses of +1.50 D OU. Participants looking at the green part of the R/G test during retinoscopy procedure. Noncycloplegic retinoscopy was not obtained on all participants. The sphere and cylinder were the foundation for the N ret SER value.

Fused cross cylinder:

Started from addition 2,00 D (verified that vertical lines are clearer than horizontal). Reduced plus by 0,25 D step until horizontal lines are clearer, than added plus by 0,25D step until equal.

Accommodation:

Positive Relative Accommodation (PRA)/Negative Relative Accommodation (NRA) to sustainable blur.

Phoria assessment:

Measured with Howells phoria card for both distance (3m) and near (33cm). At near also assessed with ±1.00 D.

Trial frame over refraction (not used after 16. March 2020 due to Covid-19 safety precautions):

Best subjective refraction from the phoropter was inserted in a trial frame to adjust distance correction with a ± 0.25 D flipper. Participant was asked which prescription feel more comfortable. Used RG test to reassure no G>R result. If the value differed from the phoropter-value, the new value overwrote the old phoropther-value.

Anterior chamber angle:

van Herick method. Measured with slitlamp TopCon SL-4F.

Cycloplegic autorefraction measurement (C auto):

1 drop of Cyclopentolate Hydrochloride 1,0% minims (Bausch Health Ireland Ltd), instilled into the conjunctival sac in each eye. 2 drops in each eye if the patient had dark coloured iris. Cycloplegic measurements were conducted at the earliest 30 minutes after instillation of last drop and at the latest at 50 minutes after instillation, with a mean of 36 minutes and a SD of ± 5 minutes.

Three to six readings on each eye 30-60 minutes after insertion, always conducted on the RE first. The measurements were executed by the Topcon KR-800. The sphere and cylinder were the foundation for the C auto SER value and is set as the gold standard for this study.

3.3 Questionnaire

Participants completed a questionnaire (Annex 2) with 35 questions mainly about the characteristics of their myopia (onset, progression, myopia in family etc.) and their use of smartphone and other digital units. The questionnaire took approximately 3-5 minutes to complete.

3.4 Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 26.0, and the significance level was set to < 0.05.

Spherical equivalent refractive (SER) errors were calculated for the four different types of refractive methods compared in this study. All values of refraction reported are SER errors. The cycloplegic autorefraction is set as the gold standard of refraction, and the degree and onset of myopia are defined in the Definition part on page 7. Inclusion criteria was SER ≤ -0.50 D by subjective refraction, but the defined degree of myopia is based on the cycloplegic autorefraction (C auto) on right and left eye of each participant.

Several statistical analysis methods were applied. Preliminary analyses for assessing normality were conducted by histogram, Q-Q plot, boxplot and Kolmogorov-Smirnov test. Outliers were excluded from the study after thorough evaluation of each outlier.

The non-normal data were assessed with Mann-Whitney U-test, Wilcoxon Signed Rank test and Spearman rho. Despite correlation between right and left eye, there was consequently higher mean differences in the right eye than in the left eye (Table 1, 2 and 3). Noncycloplegic autorefractor measurements were consequently conducted on the right eye first, which makes it possible for proximal accommodation to have influenced the readings. To eliminate this possible source of error, data of the left eye was chosen.

3.5 Ethical considerations

The study was approved by the Regional Committee for Medical and Health Research Ethics in Southeast Norway (REK) [Ref: 2018/2476] and Norwegian Centre for Research Data (NSD), and was carried out in compliance with the principles of the Declaration of Helsinki. All participants were given oral and written information about the study together with a consent form (Annex 1). Written consent was obtained by all participants prior to inclusion in the study. The written and oral information included that participation was voluntary and that they at any time could withdraw the consent without any further explanation.

Participants of the study went initially through a routine eye examination with standard non-invasive procedures. If any pathology were suspected or discovered, the participant was referred to the appropriate health-care provider. Further participation and examination included the use of Cyclopentolate Hydrochloride 1 %, which is a muscarinic antagonist, to paralyze the ciliary muscle and respectively the accommodation. The use of cycloplegic eye drops is a standard optometric procedure, but mostly used on indication in the adult population. The participant feels a burning sensation right after insertion of the eye drops that typically lasts for less than 60 seconds. Some of the side-effects of Cyclopentolate is photophobia due to a larger aperture of the pupils and blurred near-vision. The accommodation regains its normal function after 3-4 hours, and the pupil size normalizes after approximately 24 hours. To reduce the risk of serious side effects, participants with a narrow chamber angle were excluded from the study and therefore not dilated. In the consent form (Annex 1), the participants were informed of the side-effects of Cyclopentolate. In case of allergic reaction or acute narrow-angle glaucoma, an EpiPen adrenaline 0.3 mg auto-injector (Meda Pharma GmbH & Co KG) and pilocarpine nitrate 2% minims (Bausch Health Ireland Ltd) were available in the optometric practice. Before the participants left the practice on completion of the examination, they received written information about what to do and who to contact if they should experience any unexpected reactions to the muscarinic antagonist. All examinations followed the clinical guidelines recommended by the Norwegian Association of Optometry.

On completion of data collection, the measurements were transferred from the journal to SPSS for statistical analysis. The customer number of the recruited patient was replaced with a unique identification number to ensure anonymity of the participants. The decoding list is kept separately and in a locked cabinet and will be deleted on the 10. July 2026.

The results of the study will, in addition to oral examination at the Master's Thesis presentation, be presented at the educational seminar of Brilleland and Interoptik in 2021.

4 Results

4.1 Study population

50 initial participants were reduced to 44 due to criteria set for participating and through evaluation of the gathered data. After collecting the data, 3 participants came forward with additional information about their health and therefore had to be excluded. 1 participant was emmetropic according to cycloplegic measurement that led to exclusion. 2 participants with severe myopia (< -8.00 D) were also excluded from the study after thorough evaluation.

According to cycloplegic autorefractor values of the left eye of the 44 participants,
65.9 % (N = 29) had mild myopia, 31.8 % (N = 14) had moderate myopia and 2.3 %
(N = 1) had severe myopia. The range of the spherical equivalent refractive error (SER) was -6.00 D to -0.50 D with a mean of -2.67 D and a SD of ± 1.64 D.
Onset of myopia ranged from 7 years to 25 years, with a mean onset of 15.3 years and a SD of 4.1 years. 85.7 % of the moderate myopes had onset before the age of 15, and 90.9 % of the participants with an onset after 15 years of age were mild myopes.
All 4 initial severe myopic participants (3 were excluded), had an onset before the age of 15. 81.4 % were working and 18.6 % were students or combining studies and work.
85.4 % of the participants had the smartphone as their preferred digital unit. 69.8 % of the participants used digital units for a minimum of 5 hours on a regular weekday, and 53.5 % used digital units more than 7 hours. 38.6 % of the participants used their smartphones for a minimum of 3 hours on a regular weekday, only 6.8 % use their smartphone more than 7 hours. 88.6 % of the participants used their smartphones often or always in situations that involve waiting or inactivity. 57.5 % of the participants reported looking at their smartphone, a book or a digital unit while waiting for their eye examination.

4.2 Refractive errors and differences

The refractive error of the sample, here presented by cycloplegic spherical equivalent autorefraction of the left eye (gold standard), ranged from -6.00 D to -0.50 D with a mean spherical equivalent (SE) of -2.67 ± 1.64 D. When looking at the habitual correction of the participants when they were recruited, 20.5 % of these got a reduction in myopic prescription after examination. 88 % of these reductions in prescription were found without cycloplegic refraction.

The refractive errors of the four different methods of refraction are displayed in Table 1, presented as a spherical equivalent refraction (SER) of noncycloplegic autorefraction, noncycloplegic subjective refraction, noncycloplegic retinoscopy and cycloplegic autorefraction with mean, SD, median, minimum, maximum and range. Both mean and median values show that the noncycloplegic autorefraction yields a more negative value when compared with the other three methods. Noncycloplegic retinoscopy values are closest to the values obtained by cycloplegic autorefraction.

The four methods of measurement are listed in Table 1 in the same order as they were conducted during the eye examination(s).

Table 1

Descriptive statistics for all spherical equivalent refractive (SER) values.

Variable	N	Mean	SD	Median	Minimum	Maximum	Range
N auto RE	44	-3,09	1,58	-2,75	-6,13	-0,50	5,63
N auto LE	44	-3,10	1,70	-2,50	-6,88	-0,63	6,25
N subj RE	44	-2,83	1,58	-2,44	-5,88	-0,50	5,38
N subj LE	44	-2,90	1,66	-2,25	-6,38	-0,63	5,75
N ret RE	41	-2,53	1,64	-2,38	-6,00	0,38	6,38
N ret LE	41	-2,63	1,74	-2,13	-6,50	0,00	6,50
C auto RE	44	-2,59	1,55	-2,31	-5,63	-0,13	5,50
C auto LE	44	-2,67	1,64	-2,06	-6,00	-0,50	5,50

N auto RE/LE = Noncycloplegic autorefraction right eye/left eye
N subj RE/LE = Noncycloplegic subjective refraction right eye/left eye
N ret RE/LE = Noncycloplegic retinoscopy right eye/left eye
C auto RE/LE = Cycloplegic autorefraction right eye/left eye

A statistically significant difference was found in the comparisons between noncycloplegic autorefraction and cycloplegic autorefraction of both right eye ($z = -5.53$, $p < 0.001$, with a large effect size ($r = 0.59$)) and left eye ($z = -5.47$, $p < 0.001$, with a large effect size ($r = 0.58$)). Statistically significant differences were also found between noncycloplegic autorefraction and noncycloplegic subjective refraction of both right eye ($z = -4.36$, $p < 0.001$, with a medium effect size ($r = 0.46$)) and left eye ($z = -4.42$, $p < 0.001$, with a medium effect size ($r = 0.47$)) and between noncycloplegic subjective refraction and cycloplegic autorefraction of both right eye ($z = -4.20$, $p < 0.001$, with a medium effect size (0.45)) and left eye ($z = -3.58$, $p < 0.001$, with a medium effect size ($r = 0.38$)). The difference between cycloplegic autorefraction and noncycloplegic retinoscopy was not statistically different of neither the right eye ($z = -0.98$, $p > 0.05$, with a low effect size ($r = 0.11$)) nor the left eye ($z = -1.06$, $p > 0.05$, with a low effect size ($r = 0.12$)). The p-values can be seen in Table 2.

Table 2

Mean difference, median difference, level of statistical significance, and the limits of agreement within each pair of methods to be compared at the 95% confidence level.

Variable	N	Mean	SD	p	Median	Minimum	Maximum	Range	Limits of agreement Mean - 1.96 * SD	Mean + 1.96 * SD
N auto RE vs C auto RE	44	-0,50	0,40	**< 0.001**	-0,50	-2,00	0,13	2,13	-1,29	0,29
N auto LE vs C auto LE	44	-0,43	0,37	**< 0.001**	-0,38	-1,75	0,00	1,75	-1,16	0,31
N auto RE vs N subj RE	44	-0,26	0,32	**< 0.001**	-0,25	-1,25	0,63	1,88	-0,88	0,36
N auto LE vs N subj LE	44	-0,20	0,31	**< 0.001**	-0,25	-1,00	1,13	2,13	-0,82	0,41
N subj RE vs C auto RE	44	-0,24	0,37	**< 0.001**	-0,19	-1,75	0,50	2,25	-0,97	0,48
N subj LE vs C auto LE	44	-0,22	0,41	**< 0.001**	-0,19	-1,88	0,50	2,38	-1,03	0,58
C auto RE vs N ret RE	41	-0,04	0,33	0.325	0,00	-0,75	1,00	1,75	-0,70	0,61
C auto LE vs N ret LE	41	-0,02	0,33	0.290	-0,13	-0,63	1,25	1,88	-0,66	0,62

Significant associations are shown in bold. $p < 0.05$ was considered statistically significant.
N auto vs C auto = SER of noncycloplegic autorefraction - SER of cycloplegic autorefraction
N auto vs N subj = SER of noncycloplegic autorefraction - SER of noncycloplegic subjective refraction
N subj vs C auto = SER Noncycloplegic subjective refraction - SER cycloplegic autorefraction
C auto vs N ret = SER Cycloplegic autorefraction - Noncycloplegic retinoscopy

There was a strong, positive correlation of all the comparisons of mean difference between the right and the left eye ($r = 0.63$, $r = 0.50$, $r= 0.63$, $r=0.74$, respectively, $p \leq 0.001$), but there are more negative mean differences in the right eye than the left. Measurements from the autorefractor were always conducted on RE first and it raised a question whether proximal accommodation was a source of error for the measurements of the right eye (see Table 3). The rest of the results presented, and statistical analyses are therefore conducted on the left eye. As shown in Table 3 there was a higher percentage of right eyes with mean differences of ≥ 0,50 D or > 0.50 D.

Table 3

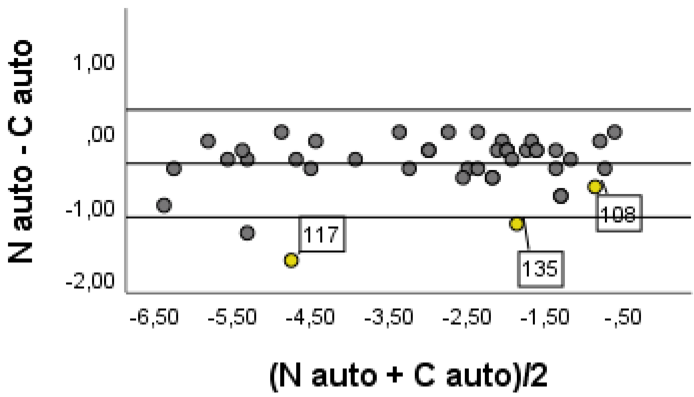
Assessing the mean differences between 3* methods of refraction of right eye and left eye ≥ 0.50 D or > 0.50 D.

	N auto vs C auto		N auto vs N subj		N subj vs C auto	
	≥ 0.50 D	> 0.50D	≥ 0.50 D	> 0.50D	≥ 0.50 D	> 0.50D
Right eye RE	58.1%	34.9%	23.3%	14.0%	20.9%	11.6%
Left eye LE	37.2%	23.3%	23.3%	4.7%	14.0%	**7,00 %**

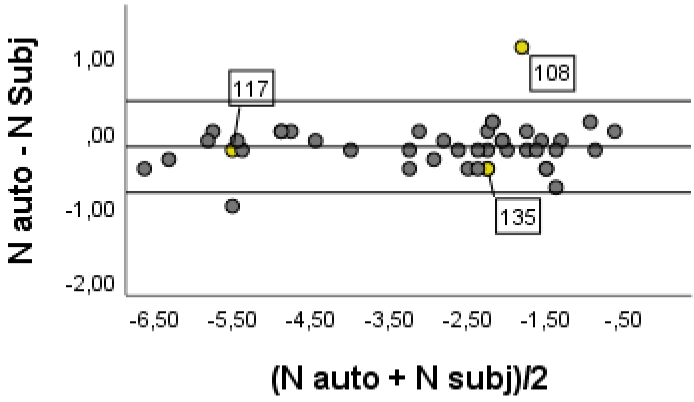
*Cycloplegic autorefraction vs noncycloplegic autorefraction is not included in this table due to the nonsignificant difference in value between the two methods.

To graphically analyse the agreement between measurements achieved with the different methods, plots of differences as a function of the mean of each pair of technique are displayed in Figure 1. This analysis allows detection of any trend in difference variability as a function of the mean value to be measured.

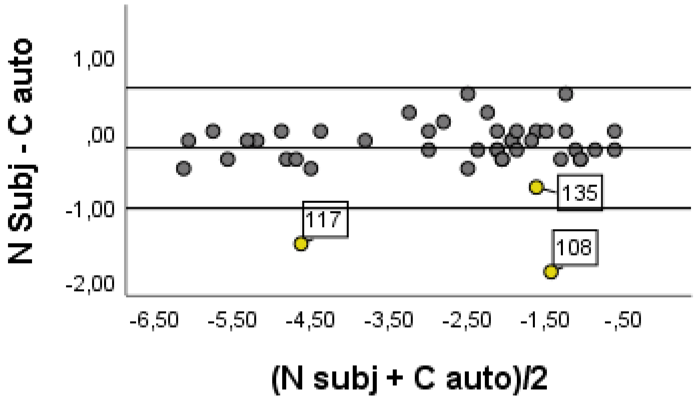
Figure 1a-d: Bland Altman plots of difference vs mean of refractive error values obtained with noncycloplegic and cycloplegic autorefractor, noncycloplegic subjective refraction and noncycloplegic retinoscopy. 3 participants that are of particular interest are marked.



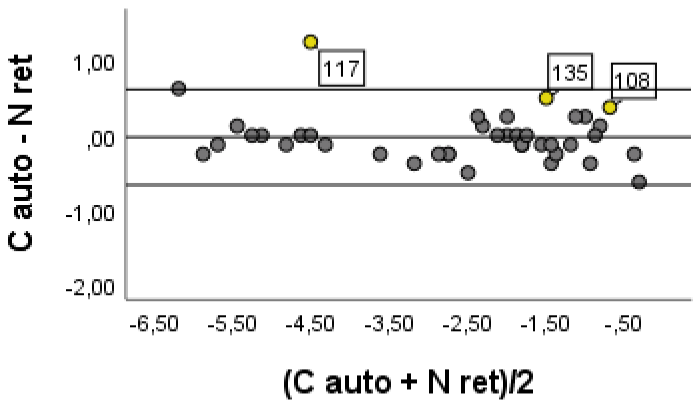
a) Noncycloplegic autorefraction and cycloplegic autorefraction.



b) Noncycloplegic autorefraction and noncycloplegic subjective refraction.



c) Noncycloplegic subjective refraction and cycloplegic autorefraction.



d) Cycloplegic autorefraction and noncycloplegic retinoscopy.

Participant 108, 117 and 135 are marked in the plots as these are participants of particular interest. In Figure 1b and 1c it is visible that participant 108 is pseudomyopic. 108 is plotted on the positive side of the y-axis in Figure 1b, meaning the participant wanted more myopic prescription subjectively than the noncycloplegic autorefractor measured. On the next figure, 108 is far over on the negative side of the y-axis, as the cycloplegic autorefractor measurement was much less myopic than noncycloplegic subjective refraction. Participant 117 is also pseudomyopic as there is a significant difference in all methods compared against the cycloplegic autorefraction, and almost no difference between noncycloplegic autorefraction and noncycloplegic subjective refraction. The pseudomyopia of participant 117 was exclusively discovered by cycloplegic autorefraction. Participant 135 is similar of 117, but in a lesser degree.

4.3 Comparisons

To find out if the differences of refractive value found in the measurements were due to recent years change in mass media habits, we needed to explore whether there were associations between higher differences of measurements and an extensive use of smartphones and/or digital units. In the following investigations, the difference measured between the noncycloplegic and cycloplegic autorefraction was the baseline for the statistical analyses. It was also explored if onset, degree of myopia and accommodative lag were associated with higher differences or pseudomyopia/NITM.

4.3.1 Use of digital units and smartphones

Participants who used digital units more than 7 hours on a normal weekday did not have significantly higher differences (Median (Md) = - 0.38, n = 20) than those who used digital units for less than 7 hours ((Md = - 0.25, n = 23), U = 230, z = - 0.01, p = 0.99, r = 0.001). Same results were found for the use of smartphones. Those who used their smartphone more than 3 hours on a regular weekday (Md = - 0.38, n = 17), did not have higher differences than those who used it less than 3 hours ((Md = - 0.25, n = 27), U = 184, z = - 1.11, p = 0.27, r = 0.17)
There were no difference between those who looked at their smartphone, a book or a digital unit while waiting for their examination (Md = - 0.38, n = 23) and those who did not ((Md = - 0.38, n = 17), U = 184, z = - 0.33, p = 0.74, r = 0.05).

4.3.2 Onset

Early onset myopes (EOMs) (Md = - 0.38, n = 21) did not have significantly higher differences than the late onset myopes (LOMs) ((Md = - 0.25, n = 22), U = 212, z = -0.47, p = 0.64, r = 0.07).

4.3.3 Degree of myopia

Mild myopes (Md = - 0.25, n = 29) did not reveal a significantly higher difference than moderate myopes ((Md = - 0.38, n = 14), U = 189, z = - 0.37, p = 0.71, r = 0.06). There were only one severe myope amongst the participants, hence severe myope could not be evaluated.

4.3.4 Accomodative lag

There were found significantly higher differences in the participants with a lag of accommodation ≤ 0.50 D (Md = - 0.56, n = 14) than of those with a lag of accommodation ≥ 0.75 D ((Md = - 0.25, n = 28), U = 71, z = - 3.38, p = 0.001, r = 0.52)). Looking at the difference in values between noncycloplegic subjective refraction and cycloplegic autorefraction, there were also found higher difference in the participants with lag ≤ 0.50 D (Md = - 0.31, n = 14) than those of lag ≥ 0.75 D ((Md = - 0.13, n = 28), U = 122, z = - 2.02, p = 0.044, r = 0.31). This means that myopes with lag of 0.50 D or lower are more susceptible of having pseudomyopia and NITM.

5 Discussion

In this cross-sectional study, four different methods of refraction were compared to investigate the incidence of pseudomyopia and nearwork-induced transient myopia (NITM) in young Norwegian adults between the age of 18 and 40, and to explore whether a potential finding could be explained by the use of smartphone and digital units at near. Participants also answered a questionnaire to provide knowledge about young myopic adults and how their media habits possibly have an impact on refraction measurements. The results are of clinical importance for optometrists in pursuance of correct refraction measurements. A sub aim was also to investigate the need of cycloplegic refraction in Norwegian myopic adults between 18 and 40 years old.

The first measurement of refraction the participants encounter is the noncycloplegic autorefractor measurement performed with the TopCon KR-800. This is a conventional closed-loop autorefractor, using fogging method to avoid accommodation during measurements. A study by Kuo et al. in Taiwan aimed to evaluate the accuracy of noncycloplegic and cycloplegic autorefraction, by comparing two different autorefractors (one being the TopCon KR-800) with cycloplegic retinoscopy. The research was conducted on children and adolescent aged 6 -17 and concluded that the TopCon KR-800 had a tendency to over-diagnosis myopia without cycloplegia, but still showed good agreement with retinoscopy. The sensitivity (the ability to correctly identify myopia) was 0.99 without cycloplegia and 0.95 with cycloplegia in the 12-17 age group, and the specificity (the ability to correctly identify non-myopic eyes) was in the same group 0.74 without cycloplegia and 0.86 with cycloplegia. As the autorefractor is compared to the cycloplegic retinoscopy, this means that the TopCon KR-800 in this study had a more hyperopic shift than the retinoscopy. The diagnostic accuracy of the autorefractor was calculated to be 0.98 without cycloplegia and 0.99 with cycloplegia(Kuo, Wang, & Chiu, 2020). Instrument myopia, where perceived near distance of enlarged images stimulates too much proximal accommodation (response to perceived distance), may not be adequately neutralized by fogging method. (Nayak, Ghose, & Singh, 1987) In this present study, data from the left eye were chosen as there was consequently higher mean differences in the right eye than in the left eye (Table 3). When the autorefractor starts to measure, the fixation target needs to be adjusted to reduce the accommodation. Since measurements were conducted on the right eye first, it is possible that the accommodation was not adequately relaxed by the fogging technique before measuring the left eye as reported by Nayak et al. (1987).

Optometrist needs to be observant of this possible source of error from the eye that gets measured first.

The highest agreement with the spherical equivalent (SE) of cycloplegic autorefraction was seen for the spherical equivalent of noncycloplegic retinoscopy (Table 1 &Table 2). The measurements from the autorefractor confirm the tendency to over-diagnose myopia without cycloplegia by a mean difference of approximately 0.4 D in the left eye when the noncycloplegic and the cycloplegic autorefraction mean differences are compared (Table 1 & Table 2). When comparing the mean of autorefractor measurements with the mean of noncycloplegic subjective refraction, there was a hyperopic shift of 0.23 D with cycloplegic autorefraction, and a myopic shift of 0.20 D with noncycloplegic autorefraction (all from the left eye). Similar results have been found in other studies. A research of noncycloplegic refraction methods concluded that retinoscopy was a more accurate starting point for subjective refraction than autorefraction (Jorge et al., 2005). Others have found autorefractors to be more accurate under cycloplegic conditions than noncycloplegic autorefraction and subjective refraction (Choong, Chen, & Goh, 2006; Hashemi et al., 2016).

The research found no association between the use of smartphone and digital units and an eventual pseudomyopia or NITM. The number of participants in this study was limited, and there is need for a larger study to be able to confirm the non-significant result. There was a significant association between low accommodative lag and a higher difference between the noncycloplegic autorefraction or subjective refraction and cycloplegic autorefraction. As pseudomyopia also is known as an accommodative excess (Scheiman & Wick, 2002, p. 349) this finding confirms that patients who tends to overaccommodate can have low accommodative lag and are more susceptible for pseudomyopia. Optometrists should bear this in mind when they perform the cross-cylinder test.

If the limit for pseudomyopia is set at SER value > 0.50 D difference between the noncycloplegic subjective measurement and the cycloplegic autorefractor measurement, there is according to the present study a chance of pseudomyopia in 7 % of the Norwegian adult myopic population between 18 and 40 years of age. This 7 % represent the three participants marked in the Bland-Altman plots (Figure1), participant 108, 117 and 135. Participant 108 raised suspicions of pseudomyopia during the subjective refraction and would have undergone cycloplegic refraction disregarding this study.

This leaves 2 participant out of 44, 4,5% of the sample, who would not have been detected as pseudomyopic by the optometrist without conducting cycloplegic measurements. These two were asymptomatic patients who rarely or never experienced headaches, fatigue and blurred vision according to their answer in the questionnaire. Participant 117 accepted 0.50 D less myopic prescription than before the examination, but had to be left with 0.75 D more minus than the cycloplegic autorefractor value. Participant 135 did not accept any change, and continued with 0.75 D more minus than the cycloplegic autorefraction as before the examination. Due to tonic accommodation, the minor rest of active accommodation when looking at far, it is customary by clinical experience to give approximately 0.50 D more of myopic prescription when prescribing for a final optical correction in this particular age group and ametropia. This also calls for the importance of accurate noncycloplegic subjective refractions and lend some justification to why it is reasonable to set the limit for pseudomyopia at differences > 0.50 D between the noncycloplegic subjective measurement and the cycloplegic autorefraction.

If the noncycloplegic subjective refractions in this study would have had absolute agreement with the noncycloplegic autorefractions, and neither noncycloplegic retinoscopy nor cycloplegic autorefraction were conducted, the optometrist would overlook pseudomyopia in 23,3% of the participants in this group of myopic Caucasians between the age of 18 and 40 years. That equals almost 1 in 4.

To reduce the risk of overprescribing minus, it is recommendable to imply these 5 procedures or advises in the noncycloplegic subjective refraction.

1: Outprint from autorefractor. Avoid starting the refraction with the full prescription from the noncycloplegic autorefractor measurement.

2: The duochromatic test (R/G test). If the green side is clearer, the patient is accommodating or being psuedomyopic. Add plus / reduce minus by 0.25 D step until equal between red and green side is achieved, or the red side is marginally better. The procedure is performed after monocular visual acuity testing, both on wearers of contact lenses and glasses.

3: Blurring for balancing test. Add plus / reduce minus until a maximum of Snellen = 0.8 is achieved. Confirm the reduced visual acuity by testing the patient. Perform the duochromatic test again (binocularly) before prescribing.

4: Perform retinoscopy to support your final prescription. According to this study a hyperopic shift > 0.50 D might indicate pseudomyopia and a need for cycloplegic refraction.

5: Fused cross cylinder. Always measure this, even in young patients. Be aware of pseudomyopia if there is a low accommodative lag or lead (< 0.75 D).

In this study it is difficult to differentiate between pseudomyopia and nearwork-induced transient myopia (NITM) in our findings of more negative value in the noncycloplegic autorefractor measurements. NITM is also pseudomyopia, but it is induced by near work and decay over time when focus is shifted from near to distance. Presumably there can be pseudomyopia that derived from NITM and there can probably be combinations of both. An initial theory of NITM being the reason for right eye yielding more negative noncycloplegic autorefractor values was discarded because of the high percentage of participants who were recruited on their contact lens examination. 64,3 % of the participants did not encounter the autorefractor before 15-20 minutes into the examination. Even though research have reported decay time of 1 hour and more (Z. Lin, Vasudevan, Liang, et al., 2012) it is more likely that the unevenness between the right and the left eye can be explained by proximal accommodation.

There are several limitations to this study. The study sample was small which effect the power of the statistical analyses, and the results of a non-significant effect needs to be confirmed in a larger study. Findings may only be relevant for Caucasian aged 18-40 and myopic, and not to other ethnicities, other ametropia or other age groups. It was only the spherical equivalent being compared in this study, not astigmatism or axis. All measurements in this study have been conducted by one experienced optometrist (MH) with the same instruments on all participants. Data have been gathered from a standard optometric examination in an optometric practice. Consequently, the measurements have not been masked. The optometrist had knowledge and access to all values from all instruments, as this is the normal setting in an optometric practice. This means that there is a possibility that one known measurement can influence another. With retinoscopy lenses of +1.50 D, the working distance is expected to be 67 cm. This has not been measured up on each examination and therefore there can be some discrepancy in the measurements of retinoscopy. There is also no control group in this study. A group of participants with washout (looking at a distance target for 15minutes prior to noncycloplegic autorefraction and further examination) and the other group being instructed to use their smartphone for 15 minutes prior to examination could have made it easier to detect eventual NITM. If the study were conducted in another setting than an optometric practice and with another procedure of

recruitment, this would probably be a better study model. Most of the participants were recruited on their routine contact lens examination, hence they did not encounter the autorefractor before 15-20 minutes into the examination.
Response bias where the participants respond untruthfully or inaccurately can affect the data set. There is a possibility that some of the responses regarding time usage of smartphones or digital units e.g. are under-reported as it can be seen as a bad behaviour. The onset of myopia is also difficult to verify as it is based on the participants self-report and not from optometric journals. Have they reported when they started to have symptoms of myopia, or e.g. when they got their first pair of glasses? The phrasing of some of the questions in the questionnaire made the participants uncertain, and guidance was needed to avoid misunderstanding.

Optometrists are healthcare providers who are highly trusted by their patients. Optometrists are the first choice for most people when in need of primary vision care. Even though this was a small sample size, also in regards of age, range and ethnicities, the present study shows that the percentage of patients with pseudomyopia is relatively low. 7 % were pseudomyopic, and only 2 out of 44 participants went undiscovered without cycloplegic refraction. 95.5 % of Caucasian myopic between 18 and 40 years old were correctly prescribed for without cycloplegic refraction, and the two participants with undiscovered pseudomyopia were asymptomatic without any asthenopia, headaches or blurred vision. The percentage of pseudomyopic participants in this study is calculated from the number of participants who had a difference of > 0.50 D between the noncycloplegic subjective measurement and the cycloplegic autorefraction, not from what their prescription were before the examination. Of the 39 participants with absolute knowledge of habitual prescription prior to the examination, 20.5 % of these got a reduction in myopic prescription, 88 % of these reductions in prescription were found without cycloplegic refraction. But as most of the participants were contact lens wearers who regularly undergo eye examinations, it also means that possibly 20.5 % of Norwegian myopic adults between 18 – 40 years old are overprescribed.

By conducting standard noncycloplegic measurement in a certain manner, the optometrist can experience that pseudomyopia is easier to both discover and to prevent from happening. In cases of symptomatic patients where findings point in the direction of pseudomyopia, one should always choose to perform cycloplegic refraction. In cases where there are asymptomatic and perfectly content patients, one have to justify the cycloplegia for the patient as it is an invasive and time-consuming method which does not necessarily end up with any other conclusion than to carry on as before.

The number of participants in this study was limited, and the result of a non-significant effect needs to be confirmed in a larger study. These results apply to young adults with myopia only, other refractive status (e.g. hypermetropia and astigmatism) and younger or older patients are not the scope of this thesis and are not discussed.

6 Conclusion

There are significant differences between the refractive values of all methods ($p < 0.05$) except the cycloplegic autorefraction and the noncycloplegic retinoscopy. There was an incidence of 7% pseudomyopia among the participant when comparing the cycloplegic autorefraction with the noncycloplegic subjective refraction (difference > 0.50 D), where 4.5 % would not have been detected without cycloplegic refraction. 20.5 % of the participants got less myopic prescription after participating, 88 % of these reductions in prescription were found without cycloplegic refraction. The results from this study indicate that by being conscious about the choice of procedures for noncycloplegic subjective refraction, there might not be a need for using more cycloplegia in the young myopic patients than what is the standard procedure in the present optometric practice today. No significant association between the use of digital units or smartphones and pseudomyopia and NITM was found in this sample of young myopic adults. A larger sample is recommended to confirm these results.

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List of tables and charts

SER = sphere + (cylinder/2)

Table 1 Descriptive statistics for all spherical equivalent refractive (SER) values.

Variable	N	Mean	SD	Median	Minimum	Maximum	Range
N auto RE	44	-3,09	1,58	-2,75	-6,13	-0,50	5,63
N auto LE	44	-3,10	1,70	-2,50	-6,88	-0,63	6,25
N subj RE	44	-2,83	1,58	-2,44	-5,88	-0,50	5,38
N subj LE	44	-2,90	1,66	-2,25	-6,38	-0,63	5,75
N ret RE	41	-2,53	1,64	-2,38	-6,00	0,38	6,38
N ret LE	41	-2,63	1,74	-2,13	-6,50	0,00	6,50
C auto RE	44	-2,59	1,55	-2,31	-5,63	-0,13	5,50
C auto LE	44	-2,67	1,64	-2,06	-6,00	-0,50	5,50

N auto RE/LE = Noncycloplegic autorefraction RE/LE
N subj RE/LE = Noncycloplegic subjective refraction RE/LE
N ret RE/LE = Noncycloplegic retinoscopy RE/LE
C auto RE/LE = Cycloplegic autorefraction RE/LE

Table 2

Mean difference, median difference, level of statistical significance, and the limits of agreement within each pair of methods to be compared at the 95% confidence level.

Variable	N	Mean	SD	p	Median	Minimum	Maximum	Range	Limits of agreement Mean - 1.96 * SD	Limits of agreement Mean + 1.96 * SD
N auto RE vs C auto RE	44	-0,50	0,40	**< 0.001**	-0,50	-2,00	0,13	2,13	-1,29	0,29
N auto LE vs C auto LE	44	-0,43	0,37	**< 0.001**	-0,38	-1,75	0,00	1,75	-1,16	0,31
N auto RE vs N subj RE	44	-0,26	0,32	**< 0.001**	-0,25	-1,25	0,63	1,88	-0,88	0,36
N auto LE vs N subj LE	44	-0,20	0,31	**< 0.001**	-0,25	-1,00	1,13	2,13	-0,82	0,41
N subj RE vs C auto RE	44	-0,24	0,37	**< 0.001**	-0,19	-1,75	0,50	2,25	-0,97	0,48
N subj LE vs C auto LE	44	-0,22	0,41	**< 0.001**	-0,19	-1,88	0,50	2,38	-1,03	0,58
C auto RE vs N ret RE	41	-0,04	0,33	0.325	0,00	-0,75	1,00	1,75	-0,70	0,61
C auto LE vs N ret LE	41	-0,02	0,33	0.290	-0,13	-0,63	1,25	1,88	-0,66	0,62

Significant associations are shown in bold. $p < 0.05$ was considered statistically significant.
N auto vs C auto = SER of noncycloplegic autorefraction - SER of cycloplegic autorefraction
N auto vs N subj = SER of noncycloplegic autorefraction - SER of noncycloplegic subjective refraction
N subj vs C auto = SER Noncycloplegic subjective refraction - SER cycloplegic autorefraction
C auto vs N ret = SER Cycloplegic autorefraction - Noncycloplegic retinoscopy

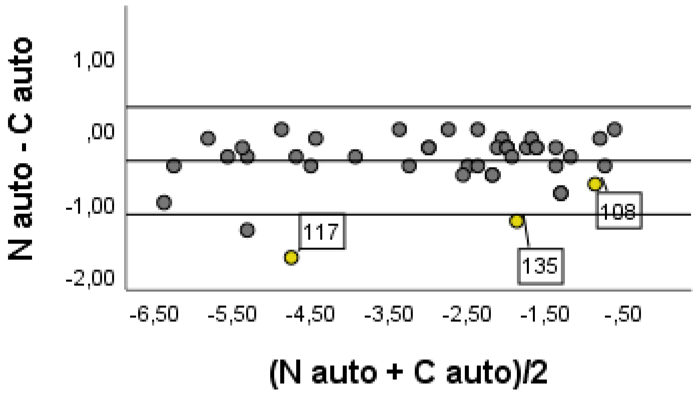
Table 3

Assessing the mean differences between 3* methods of refraction of right eye and left eye ≥ 0.50 D or > 0.50 D.

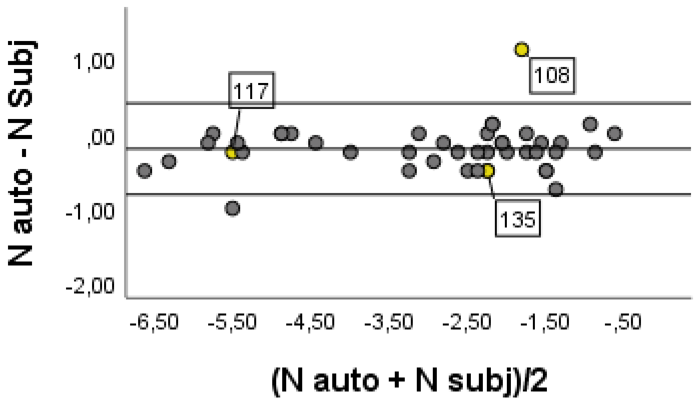
	N auto vs C auto		N auto vs N subj		N subj vs C auto	
	≥ 0.50 D	> 0.50D	≥ 0.50 D	> 0.50D	≥ 0.50 D	> 0.50D
Right eye RE	58.1%	34.9%	23.3%	14.0%	20.9%	11.6%
Left eye LE	37.2%	23.3%	23.3%	4.7%	14.0%	**7,00 %**

*Cycloplegic autorefraction vs noncycloplegic autorefraction is not included in this table due to the nonsignificant difference in value between the two methods.

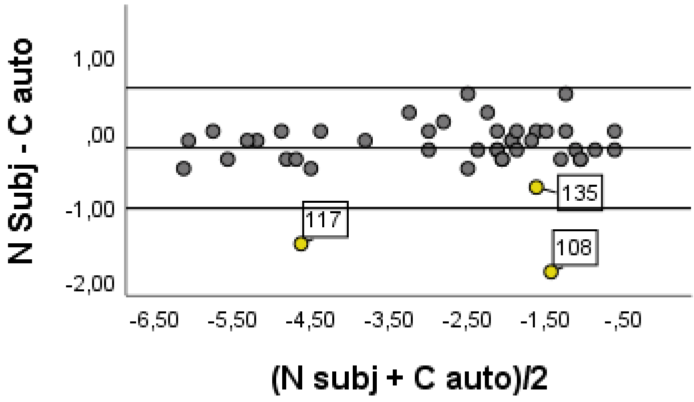
Figure 1a-d: Bland Altman plots of difference vs mean of refractive error values obtained with noncycloplegic and cycloplegic autorefractor, noncycloplegic subjective refraction and noncycloplegic retinoscopy. 3 participants that are of particular interest are marked.



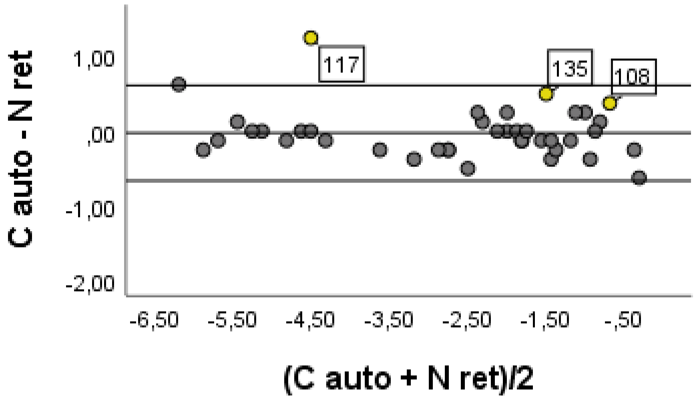
a) Noncycloplegic autorefraction and cycloplegic autorefraction.



b) Noncycloplegic autorefraction and noncycloplegic subjective refraction.



c) Noncycloplegic subjective refraction and cycloplegic autorefraction.



d) Cycloplegic autorefraction and noncycloplegic retinoscopy.

Annexes

Annex 1: Consent Form

Vil du delta i forskningsprosjektet

Pseudomyopia and nearwork-induced transcient myopia in young Norwegian adults

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet hovedsakelig er å undersøke forekomsten av falsk nærsynthet (pseudomyopi) hos unge voksne mellom 18 og 40 år. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
Nærsynthet (myopi) øker i omfang over hele verden. Formålet med prosjektet er å undersøke om dette kan ha en sammenheng med de siste årenes endrede medievaner. Smarttelefonens inntog i markedet har bidratt til en betydelig økning i antall timer øynene fokuserer på nært. Mye nærarbeid kan føre til falsk nærsynthet/forbigående nærsynthet som kan påvirke resultatet på en synsundersøkelse.

I denne studien vil det undersøkes hvor stort dette omfanget av falsk nærsynthet er hos unge voksne. For å best belyse dette vil deltakere måtte besvare et spørreskjema om bruk av digitale medier, gjennomgå en grundig synsundersøkelse og en påfølgende synsundersøkelse med øyedråper. Cycloplegiske øyedråper vil midlertidig bedøve øyets fokuseringsmuskulatur da sammentrekninger i denne ofte er årsak til falsk nærsynthet. Dette er tilsvarende (eller mildere) øyedråper som blir brukt ved rutineundersøkelse hos øyelege og ved indikasjon hos optikere. Dråpene gir mild og kortvarig svie etter drypping, samt redusert evne til å fokusere (uskarpt syn) med maks effekt 30-60 minutter etter drypping. Dråpene vil også føre til utvidede pupiller, og dermed blir man også mer sensitiv for lys inntil effekten av dråpene blir borte. Utvidelse av pupillene vil være borte innen 24 timer. Det må beregnes totalt 1,5 til 2,0 timer på undersøkelsene inkludert spørreskjemaet som inngår i prosjektet.

Forskningsprosjektet er en masteroppgave ved Universitetet i Sørøst-Norge, Fakultet for helse- og sosialvitenskap, Institutt for optometri, radiografi og lysdesign.

Forskningsresultatet vil bli forsøkt publisert i relevante tidsskrift innenfor optometri.

Hvem er ansvarlig for forskningsprosjektet?
Universitetet i Sørøst-Norge, Fakultet for helse- og sosialvitenskap, Institutt for optometri, radiografi og lysdesign.
Masterstudent: Mari Hovland, optometrist Brilleland Grønland.
Veileder: Trine Langaas, Førsteamanuensis.

Hvorfor får du spørsmål om å delta?
Utvalget består av unge norske voksne mellom 18 og 40 år, som er nærsynte og som har synsprøve på Brilleland Grønland i perioden 15.september 2019 til 10. juli 2021. Målet er 100 deltagere. Dersom du tilfredsstiller inklusjonskriteriene, vil du bli forespurt om å delta i prosjektet når du kommer til din rutinemessige synsundersøkelse, eller du kan bli forespurt i forkant dersom du i journalsystemet ligger på rutinemessig innkalling i prosjektperioden.

Hva innebærer det for deg å delta?
Dersom du tilfredsstiller kriteriene for å kunne delta, vil du som deltaker besvare et spørreskjema om dine medievaner, gjennomgå en fullstendig synsundersøkelse inkludert drypping av øyedråper.

Bortsett fra spørreskjemaet er ingen av undersøkelsene annerledes enn det man normalt sett eller ved indikasjon vil gjennomgå på en undersøkelse av syn og øyne i henhold til kliniske retningslinjer for optikere. Styrkene registrert ved de forskjellige undersøkelsesmetodene vil bli registrert elektronisk i journalsystemet hos Brilleland AS.

Det er frivillig å delta
Det er helt frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke ditt samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg innenfor forskningsprosjektet vil være anonymisert. Det vil ikke ha noen negative konsekvenser for deg eller din videre behandling hos Brilleland AS hvis du ikke vil delta eller senere velger å trekke deg.

Forsikring
Prosjektdeltakere er dekket gjennom pasientskadeloven.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Innenfor forskningsprosjektet vil vi bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Opplysninger som hentes ut er: alder, kjønn, refraksjon (hvilke styrker vi måler), øyets fokuseringsevne, bruk av digitale enheter jmf. spørreskjema, type nærsynthet, samsynsstatus og forekomst av nærsynthet i familien. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket (GDPR).

- Opplysningene fra synsundersøkelsene vil oppbevares i Brilleland AS sitt journalsystem som følger GDPR's retningslinjer.
- Navnet og kontaktopplysningene dine vil erstattes med en kode som lagres på egen navneliste adskilt fra øvrige data. Kodenøkkel vil oppbevares i et låst arkivskap som kun er tilgjengelig for prosjektmedarbeiderne.

Ved eventuell publikasjon av forskningsresultatet vil ikke deltakerne kunne gjenkjennes da datamaterialet er anonymisert.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Prosjektet skal etter planen avsluttes 10.juli 2021. Av dokumentasjonshensyn skal opplysningene likevel bevares inntil 10.07.2026. Forskningsfilen oppbevares atskilt i en nøkkel- og en opplysningsfil. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år etter denne dato. Dette i samsvar med vilkår fra Regionale komiteer for medisinsk og helsefaglig forskningsetikk (REK). Personopplysninger fra synsundersøkelsen oppbevares på standardisert vis som ved vanlige synsundersøkelser i journalsystemet til Brilleland AS (behandlende institusjon).

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

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

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

På oppdrag fra Universitetet i Sørøst-Norge har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

REK - Regional komité for medisinsk og helsefaglig forskningsetikk har vurdert prosjektet, og har gitt forhåndsgodkjenning (Saksnr.: 2018/2476).

Du har rett til å klage på behandlingen av dine opplysninger til Datatilsynet.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Universitetet i Sørøst-Norge ved førsteamanuensis Trine Langaas, trine.langaas@usn.no
- Vårt personvernombud: Pål Are Solberg, personvernombudet@usn.no
- NSD – Norsk senter for forskningsdata AS, på epost (personvernombudet@nsd.no) eller telefon: 55 58 21 17.

Jeg bekrefter å ha gitt informasjon om prosjektet

Sted og dato | Signatur

Masterstudent og optometrist

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet Pseudomyopia and nearwork-induced transcient myopia (NITM) in young Norwegian adults, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i synsundersøkelse med og uten cycloplegiske øyedråper.
- ☐ å svare på spørreskjema.
- ☐ at relevante opplysninger innhentes av masterstudenten fra min pasientjournal i etterkant av synsundersøkelse.

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet, ca. 10.juli 2021.

(Signert av prosjektdeltaker, dato)

Annex 2: Questionnaire

Deltakernr:

Spørreskjema til forskningsprosjektet:

Pseudomyopia and nearwork-induced transcient myopia (NITM)

in young Norwegian adults

Norsk tittel: Falsk nærsynthet og nærarbeidsindusert forbigående nærsynthet hos unge norske voksne.

Ordforklaringer:

Nærsynt: Ser best på nært, dårligst på avstand. Minusstyrke. Unge nærsynte kan stort sett se godt både på avstand og nært med riktig brille- eller linsekorreksjon. Eldre nærsynte må ta avstandsbrillen av når de skal lese.

Korreksjon: Hjelpemiddelet for å gi deg klart syn; briller eller kontaktlinser.

Smarttelefon: Mobiltelefon med skjerm som kan surfes på internett med.

<: mindre enn

>: mer enn

SETT KRYSS VED DET SOM PASSER, FYLL INN DER DU BLIR BEDT OM DET:

Dato og klokkeslett for synsundersøkelsen (utfylles evt. av prosjektleder): __________________

Dato og klokkeslett for cycloplegiske øyedråper (utfylles av prosjektleder): _______________

Hvor gammel var du da du ble nærsynt? _________________________

Hvordan har din styrkeutvikling vært siden?

-Ingen endring

-Gått jevnt nedover, dvs. gradvis **mer** nærsynt

-Gått jevnt oppover, dvs. gradvis **mindre** nærsynt

-Ustabilt, dvs. gått opp og ned

Evt. kommentar til styrkeutvikling: ____

Er noen i din nære familie nærsynte? Nær familie: Foreldre, søsken, besteforeldre.

-ja

-nei

-vet ikke

Dersom ja, kryss av for hvem: Kan krysse av ved flere alternativer.

-En forelder

-Begge foreldre

-Søsken

-Besteforeldre

Foretrekker du å bruke briller eller kontaktlinser?

-Briller

-Kontaktlinser

-Bruker begge deler omtrent like mye

-Bruker hverken briller eller kontaktlinser

Dersom du bruker korreksjon, hvor ofte bruker du briller eller kontaktlinser?

-Bare ved behov på avstand

-Bare ved behov på nært

-Bare ved behov på avstand og nært

-Når jeg kommer på det eller andre (f.eks familiemedlemmer) sier at jeg må bruke det

-Daglig, ser ikke godt nok uten

Er du i arbeid?

-Ja

-Nei, er skoleelev/student

-Annet: ____

Eier du en av følgende digitale enheter? Kan krysse av ved flere alternativer.

-Smarttelefon

-Laptop

-Ipad/nettbrett

-E-bokleser

-Stasjonær PC/MAC

-Annet: ____

Hva slags digital enhet bruker du VANLIGVIS til å surfe på internett?

-Smarttelefon

-Laptop

-Ipad/nettbrett

-E-bokleser

-Stasjonær PC/MAC

-Annet:_______________________________

Hvilken digital enhet foretrekker du å kommunisere med andre på?

-Smarttelefon

-Laptop

-Ipad/nettbrett

-Stasjonær PC/MAC

-Annet: ________________________________

Hvor mange timer om dagen bruker du på din digitale enhet (spill/underholdning, surfing, kommunikasjon, arbeid osv)

<1 time

1-3 timer

3-5 timer

5-7 timer

>7 timer

Alt i alt, hva er din foretrukne digitale enhet i hverdagen?

-Smarttelefon

-Laptop

-Ipad/nettbrett

-Stasjonær PC/MAC

-Annet: ____

Hva bruker du din foretrukne digitale enhet til oftest?

-Surfing på nettet

-Kart/navigasjon

-Kommunikasjon

-Spill og underholdning

-Media (musikk/film)

-Lesing

-Arbeid

-Annet: ____

Hvordan kommer du deg VANLIGVIS til jobb/skole/annet?

-Går/jogger/Sykler

-Kjører bil/motorsykkel osv

-Tar kollektivt/medpassasjer i bil

Hva gjør du VANLIGVIS på turen til/fra jobb/skole/annet hvis du kjører kollektivt/er medpassasjer?

-Leser i bok/studerer

-Leser i e-bok/studerer

-Leser/surfer på smarttelefon

-Leser/surfer på nettbrett/laptop

-Snakker med andre

-Spiller/underholdning på smarttelefon/nettbrett/laptop/håndholdt dataspill

-Sover

-Ser ut av vinduet

-Annet: ____

Hvor lang tid bruker du VANLIGVIS på å komme deg hjemmefra til jobb/skole?

Tidsbruk: _________________________

Hvor lang tid bruker du VANLIGVIS på å komme deg hjem fra jobb/skole?

Tidsbruk: _________________________

Dersom du er skoleelev/student: Bruker du smarttelefonen i friminutt/pauser?

-Aldri

-Sjeldent

-Av og til

-Ofte

-Alltid

Dersom du er i jobb: Bruker du smarttelefonen i pauser?

-Aldri

-Sjelden

-Av og til

-Ofte

-Alltid

Bruker du datamaskin (bærbar eller stasjonær) enten hjemme eller på skole/arbeid?

< 1 time

1-3 timer

3-5 timer

5-7 timer

>7 timer

Bruker du smarttelefonen din når du venter (f.eks. til timeavtaler, møter, er på kollektiv transport osv)?

-Aldri

-Sjelden

-Av og til

-Ofte

-Alltid

På en vanlig hverdag (mandag-fredag), hvor mange timer totalt sett ser du på digitale enheter?

<1time

1-3 timer

3-5 timer

5-7 timer

>7 timer

På en vanlig hverdag (mandag-fredag), hvor mange timer totalt sett ser du på smarttelefonen?

<1time

1-3 timer

3-5 timer

5-7 timer

>7 timer

Hvor mange timer totalt hittil i dag har du sett på digitale enheter?

<1 time

1-3 timer

3-5 timer

5-7 timer

>7 timer

Hvor mange timer totalt hittil i dag har du brukt smarttelefonen?

<1 time

1-3 timer

3-5 timer

5-7 timer

>7 timer

Med korreksjon, opplever du uklart syn på smarttelefonen?

-Aldri

-Sjelden

-Av og til

-Ofte

-Alltid

Foretrekker du å se på smarttelefonen med din avstandskorreksjon eller uten?

-Med

-Uten

-Går like fint med og uten

-Vet ikke

Blir du sliten i øynene når du ser på smarttelefonen?

-Aldri

-Sjelden

-Av og til

-Ofte

-Alltid

Dersom du blir sliten, hvor lenge kan du se på smarttelefonen før du må ta deg en pause fordi du blir sliten i øynene?

-0-15 min

-15-30 min

-30-45 min

-45-60min

- Mer enn 60 min

Får du vondt i hodet når du ser på smarttelefonen?

-Aldri

-Sjelden

-Av og til

-Ofte

-Alltid

Med korreksjon, opplever du uklart syn på avstand når du skifter fokus fra nært til lang avstand? F.eks løfter blikket opp fra smarttelefonen.

-Aldri

-Sjelden

-Av og til

-Ofte

-Alltid

Har du egne databriller?

-Nei

-Ja

Dersom ja, oppleves de som uklare på avstand?

-Ja

-Nei

-Vet ikke

Hvor lenge ventet du i lokalet før undersøkelsen startet?

0-3 min

3-6 min

6-9 min

>9 min

Så du på smarttelefonen eller en annen digital enhet eller leste i bok når du ventet på å starte undersøkelsen i dag?

-Ja

-Nei

Dersom annet enn smarttelefon, hva slags enhet: ________________________________

TUSEN TAKK FOR DELTAKELSEN!