NORWEGIAN SCHOOL OF SPORT SCIENCES

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Social facilitation with the mere presence of a spotter and performance in strength tasks

An experimental deception study

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Abstract

Purpose: Sheridan et al. (2019) found that presence of passive spotters facilitated performance enhancements during bench press, enhanced self-efficacy levels, and reduced their rate of perceived exertion compared to without spotter. Sheridan et al. (2019) recommended that future research should investigate presence of spotters on different resistance exercises, and the social interaction between the spotters and participants. This study aimed to explore the impact of social facilitation on strength-related task and examine how individual trait and state anxiety levels can influence performance. Using an isokinetic dynamometer, effect of spotter presence during different approaches was investigated in both squat and bench press performance.

Methods: Twelve recreationally trained students (age, 22.4 ± 1.9 years, height, 172.1 ± 12.1 cm, and weight, 70.5 ± 13.4 kg) performed 3 trials of 2RM, 1RM, and 10RM on separate occasions in an experimental deception study. The 3 trials consisted of a spotter being passive (PS), a spotter being supportive with verbal encouragement (SS), or an alone condition (NS) (spotter hidden from view). During the trials, peak and mean force for each repetition range on both exercises and state anxiety were measured.

Results: In SS compared to NS, the group increased their 1RM squat peak force (*M* = 223.6 N, 95% CI [143.3, 303.8], p = .001, η_p^2 = .881), and mean force (*M* = 94.1 N, 95% CI [31.3, 156.9], p = 0.004, η_p^2 = .713). The 10RM testing also revealed increases in peak force (*M* = 166.5 N, 95% CI [51.5, 281.5], p = .005, η_p^2 = .616) and mean force (*M* = 81.3 N, 95% CI [10.3, 152.2], p = .024, η_p^2 = .512) in SS compared to NS. In terms of spotter effects, the male participants received the highest performance improvements.

Conclusion: For recreationally trained individuals, the presence of a supportive spotter increases squat performance in both peak and mean force during 1RM and 10RM compared to the alone condition. The information gained from this study suggests that researchers, strength coaches, and personal trainers should recognize the importance of verbal encouragement and the presence of a spotter during testing to optimize performance or the necessity for standardization to ensure consistency.

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1.0 Introduction

Recently, there has been an increase in the popularity of resistance training as a leisure activity. While modern technology has reduced the need for high levels of force production during daily activities, muscular strength has been recognized as a crucial physical trait for improved quality of life, functional ability, and overall health by medical and scientific communities (Kraemer et al., 2002, p. 364). This makes resistance exercise an area of interest for both non-competitive individuals aiming to increase their capacity for daily tasks requiring muscular effort or improving their body composition as well as competitive individuals participating in various sports (Bird et al., 2005, p. 842). Commercial gyms have expanded their team with personal trainers to guide people looking to invest in their workouts, whether for motivation, fitting exercise into their daily schedule, or developing new ideas for workout plans and program design (Scholl et al., 2012, p. 69).

Proper program design is crucial for achieving results with resistance training at any age or fitness level, which includes correct technique, proper use of equipment, goal setting, a method to evaluate progress, and knowledge of essential exercise planning principles (Kraemer & Ratamess, 2004, p. 674). It's essential to monitor training loads within an individual's exercise regime to ensure that they are experiencing the necessary training stimulus to achieve their goals during the current period. This can help coaches determine cases where individuals may not be experiencing an optimal training stimulus due to insufficient workout volume or intensity (Scott et al., 2016, pp. 687-688).

Studies have shown that having a peer present can be beneficial for physical activity. Overweight children between the ages of 8-12 were found to be less sedentary and enjoyed physical activity more when in the presence of a peer (Rittenhouse et al., 2011, p. 58). Similarly, healthy men and women walked further (13-14% increase) over a six-minute period when in a group rather than alone (Grindrod et al., 2006, p. 877). A study by Corbett et al. (2012) found that trained participants were able to cycle a 2000-meter distance faster when in a head-to-head competition rather than exercising alone (p. 514). Results for exercising while running have been mixed, with some studies showing no difference between exercising with a partner or alone on intensity, enjoyment, or perceived exertion (Carnes & Barkley, 2015, p. 266; Carnes et al., 2013, p. 3). However, Carnes et al. (2013) argued that familiarity between the partners might affect the outcome. They suggested that exercising with unfamiliar peers can lead to positive outcomes (p. 4). Guerin & Innes (1984) mentioned that we become more alert when in the presence of strangers compared to familiar individuals (p. 35). While supportive friends can be beneficial, it has also been revealed that they can impair performance on difficult tasks (Butler & Baumeister, 1998, p. 1225). Supportive audiences generated higher levels of self-focus among the participants, and high self-focus negatively correlated with performance across the entire sample (Butler & Baumeister, 1998, p. 1225). In contrast, Piché & Sachs (1982) found no differences in performance between groups of friends and strangers for exerting vertical pressure toward the floor (pp. 1213–1214).

Various studies have demonstrated that receiving supervision from qualified professionals can enhance the benefits of resistance training for both athletes and exercisers (Coutts et al., 2004, pp. 318-320; Dias et al., 2017, p. 1928; Gentil & Bottaro, 2010, pp. 642-643; Mazzetti et al., 2000, p. 1183). Research has indicated that when healthy participants engage in resistance training under the supervision of a personal trainer, they self-selected a 9-19% higher resistance intensity in various exercises as opposed to when they exercise alone (Dias et al., 2017, p. 1928; Ratamess et al., 2008, p. 107). In a 12-week periodized resistance-training program, young rugby players who received direct supervision experienced a significant increase in 3RM in both bench press and squat compared to an identical group that did the same program without supervision (Coutts et al., 2004, p. 320). Moreover, Gentil & Bottaro (2010) compared supervision ratios and found that the participants who engaged in resistance exercises with higher supervision ratios experienced the most strength gains for both the upper and lower body (p. 642).

Research on resistance exercise has primarily focused on the effects of supervision or the presence of others over an extended training period. However, there is a need for more studies on how the immediate presence of others affects the performance of resistance exercise sets or one-repetition maximum lifts. This refers not to how personal trainers or coaches participate in choices and influence the intensity of sessions but how social facilitation itself can enhance the performance of customers or athletes in a working set or by lifting more kilograms for one repetition max by the mere presence. The social aspects of resistance exercise have been largely overlooked in previous interventions and education, which have mainly focused on biomechanical, technical, physiological, and nutritional aspects (Kuklick & Gearity, 2019, pp. 290-291). In their research on social facilitation in strength tasks, Rhea et al. (2003) highlighted the potential impact of psychological and environmental factors on performance during multiple trials. They emphasized the importance of recognizing and preventing these confounding elements (p. 306). Hopkins et al. (2001, p. 230) also noted that variations in measures across similar studies could be attributed to differences in motivational methods or the level of respect and trust between subjects and researchers.

When examining the influence of behavior in social psychology, using deception can be beneficial if it is implemented with a fair cost-benefit analysis that does not cause harm or infringe on the rights of participants (Christensen, 1988, p. 670; Ortmann & Hertwig, 2002, p. 112). Aronson and Carlsmith (1968), as cited in Christensen (1988), believed that certain research questions couldn't be adequately answered without using deception (p. 670). To investigate whether social presence affects performance in strength-related tasks compared to performing those same tasks alone, a deceptive approach can be employed to prevent participants' beliefs from interfering with the data collection, as Sheridan et al. (2019) demonstrated successfully. They explained that future studies should explore a wider variety of exercises and the interaction/behavior between the spotter and the athlete (Sheridan et al., 2019, p. 1760).

2.0 Theory

2.1 Resistance exercise

Resistance exercise has gained popularity and becomes one of the fastest-growing fitness activities and forms of physical exercise. This form of exercise can help achieve various goals, such as improving overall health, enhancing athletic performance, recovering from injury or surgery, or just for pleasure (Fry, 2004, p. 664). Regular resistance training can lead to benefits like increased muscle strength, size, power, balance, endurance, and coordination. It can also lower the risk of osteoporosis, reduce body fat, improve blood lipid profiles, insulin sensitivity, and lower blood pressure, among other health benefits (Kraemer et al., 2002, pp. 165-166; Ratamess et al., 2008, p. 103). Additionally, resistance exercise can improve mental health outcomes, like reducing anxiety and pain intensity, improving cognition among older adults, reducing depression and fatigue symptoms, and improving self-esteem and sleep quality (Gordon et al., 2017, pp. 2528-2529; O'Connor et al., 2010, p. 390). Recreational resistance exercise involves training for moderate improvements in hypertrophy, muscular endurance, or muscle strength. Some individuals also exercise in competitive forms of resistance training, which include powerlifting, strongman/woman, weightlifting, bodybuilding, maintenance training, or athletics (Kraemer & Ratamess, 2004, p. 675).

2.2 Muscular strength

There are two main types of muscular assessment: strength testing and endurance testing. Muscular endurance is the ability of a muscle or group of muscles to sustain a certain level of force production over time. On the other hand, muscular strength refers to the maximum force or torque that a muscle or group of muscles can generate, or the ability of the neuromuscular system to produce force against an external resistance. (Bompa & Haff, 2009, p. 261; Strand et al., 2014, pp. 93-94). Muscular strength can be affected by several morphological and neural factors. Multifactorial mechanisms can also improve muscular strength and confounders, such as training status, genetics, and initial strength (Suchomel et al., 2018, p. 766). Research indicates that individuals can achieve superior strength-power gains by first increasing muscle hypertrophy (cross-sectional area) and work capacity (force production capacity), followed by a periodized progression (Suchomel et al., 2018, p. 767). The maximum strength an individual can attain depends on seven fundamental concepts: muscle fiber type, number of motor units recruited, motor unit synchronization, motor unit firing rate, degree of neuromuscular inhibition, use of stretch-shortening cycle, and amount of muscle hypertrophy (Bompa & Haff, 2009, p. 263).

2.3 Social facilitation

Social facilitation is one of the oldest topics in academic social psychology, and this phenomenon was early as 1898 systematically tested by Norman Triplett (Triplett, 1898; Halfmann et al., 2020, p. 332). Allport (1924), cited in Guerin (2009), first used the term social facilitation to describe "*an increase in response merely from sight or sound of others making the same movement*" (p. 1). Today this term refers to either an increase or decrease in response, and it is no longer relevant that people must do the same movement. The factors that affect one's performance in the presence of other individuals have been identified and delineated by Allport (1924) and Dashiell (1935), and those include arousal, rivalry, modeling, encouragement or social reinforcement, imitation, evaluation, distraction, and group membership (Guerin, 2009, p. 1). In this early research, they studied participants that did various tasks such as word association, problem-solving, and multiplication in groups and alone. Researchers observed a connection between the type of task and the presence of an audience at the performance (Platania & Moran, 2001, pp. 190-191).

2.3.1 Social facilitation in different contexts

The effect of other members' presence has a general problem. This phenomenon is multifaceted and often depends on the relationship between the individual under investigation and the present group members (Landers & McCullagh, 1976, p. 125). The literature has defined different paradigms for specific situational conditions identified in this domain. Those paradigms are referred to as *coaction*, *competitive coaction*, and *audience effect* (Landers & McCullagh, 1976, pp. 125-126; Rhea et al., 2003, p. 303). The paradigm of *coaction* refers to a specific situation where individuals work alongside each other while independently carrying out the same type of activity or exercise without rivalrous incentives (Lander & McCullagh, 1976, pp. 125-126; Rhea et al., 2003, p. 303). *Competitive coaction* is similar, but there is an explicit rivalry between the individuals (Landers & McCullagh, 1976, p. 126; Rhea et al., 2003, p. 303). The last paradigm, *audience effect*, refers to the effect expressed in the presence of passive spectators. These spectators do not interact with the performer but observe the performance of the specific task(s) directly (Rhea et al., 2003, p. 303; Landers & McCullagh, 1976, p. 133).

Situations where group members or audiences verbally seek to affect the subject's performance (social reinforcement or encouragement), commonly found in sports situations, are not within the social facilitation paradigm (Landers & McCullagh, 1976, p. 126). Situations, where social reinforcement, razzing, or cheering spectators occur is assumed to give an additional effect since these also contain the effects of passive coaction and audience effect on performance (Landers & McCullagh, 1976, p. 126). Social facilitation with verbal encouragement has been found to enhance performance on both sprint and endurance exercises and increase motivation to exercise in a study conducted by Edwards et al. (2018, p. 6). The size of the audience may also impact performance. According to McCullagh and Landers (1976), nervousness and activation levels increased linearly as the audience size increased from 1-6. The performance was somehow inconsistent, but the best results were observed with audience sizes of 5 and 6 members (pp. 1069-1070). Verbal feedback has also shown increased kinematic performance in upper and lower body strength compared with the no-feedback condition. It was argued that the training status (experience) and the selected exercise (the size and number of muscles involved) would get more significant improvements due to greater activation in recruit percentage and larger, more powerful muscles involved (Argus et al., 2011, p. 3285; Weakley et al., 2020, p. 3160).

To summarize, social facilitation is a well-established concept that explains how people tend to perform better in the presence of others. This phenomenon occurs in three scenarios: coaction, coaction with competition, and when there is an audience. However, it is important to note that social facilitation is a passive effect and does not involve any intentional encouragement or motivation. It is also believed that having a larger audience can further enhance the social facilitation effect, as there are more sources of stimulation.

2.3.2 Theories to explain the phenomenon

2.3.2.1 Zajonc`s Drive Theory

Various theories attempt to explain why coaction, competition, or the mere presence of others can affect performance. The most popular and accepted theory within social facilitation is Zajonc's "Drive theory", which suggests that competition or mere presence would increase one's level of arousal, leading to a linear affection on performance (Bond & Titus, 1983, pp. 265-266; Rhea et al., 2003, p. 303). This non-specific increase in activation is considered an innate reaction, which is a mechanism to prepare a living being to respond to any potentially unexpected actions by others (Strauss, 2002, p. 239). Researchers suggest that the presence of others would increase drive or arousal levels due to the uncertainty of their behaviors. As a result, when in the presence of others, a response is required, and this preparation leads to heightened arousal levels (Guerin, 1986, p. 39).

Higher drive levels will lead to the dominant or well-learned reaction more likely to be emitted. This means that a person's behavior repertoire prioritizes action on a specific stimulus over other less prioritized (subordinate) or not well-learned actions (Guerin &

Innes, 1982, p. 7; Strauss, 2002, p. 239). The theory explains that simple or well-learned tasks would improve performance with the presence of an audience, but inhibition in performance in more complex or less well-learned tasks. The literature refers to simple tasks as well-learned tasks where the performer's dominant response tends to be correct. In contrast, complex tasks refer to unlearned tasks where the dominant response tends to some incorrect responses (Bond & Titus, 1983, p. 266). The knowledge of the task characteristics and complexity would then predict the effect of the audience's presence on performance (Guerin & Innes, 1982, p. 8). Platania & Moran (2001) revealed that the participants in the audience condition had significantly more dominant responses than those in the alone condition, supporting Zajonc's drive theory (p. 196).

2.3.2.2 Baron's Distraction-and-conflict theory

According to distraction-conflict theory, coactors and audiences can increase drive by provoking attentional conflict. This model can be broken down into a series of steps, such as *others are distracting,* which indicates that species mates are provocative stimuli and will generally be desirable targets of attention (Baron, 1986, p. 4). *Distraction can lead to attentional conflict* because attending to others can defy the task demands. If the individual attends to numerous inputs, a conflict is likely to occur if the individual has an inadequate attentional capacity or inadequate physical capacity to handle both the requirements for the given task and the inputs (Baron, 1986, p. 4). The *attentional conflict increases drive* by factors such as uncertainty about what attentional response to make, the overload of processing and attending to several inputs simultaneously, or frustration due to delayed reinforcement because of response conflicts (Baron, 1986, p. 5).

The most common reason for distraction by the presence of others in a task setting is due to social comparison (Baron, 1986, p. 7; Bond & Titus, 1983, p. 266). The key idea is that the presence of others can cause distraction or divert attention away from the task at hand and cause attentional conflict regarding what attentional response the individual should make (pay attention to the task or the person present) (Belletier et al., 2019, p. 261). Situations with attentional conflict may lead to cognitive overload, which produces attentional focusing. Attentional focusing can be defined as a narrowing in attention; peripheral cues are not prioritized, while more attention is allocated to central cues (Muller et al., 2004, p. 659). This theory suggests that mere presence increases performance when the individual screening out non-essential stimuli while performing a simple task or require attention to few central cues, and impairment in performance when the task demands attention to many cues or the task is more complex by nature (Baron, 1986, pp. 5-7; Belletier et al., 2019, p. 261).

2.3.2.3 Duval & Wicklund`s Self-awareness Theory

Duval & Wicklund developed the “Self-awareness theory” that assumes that the orientation of conscious attention was the essence of self-evaluation. They suggested that the presence of others led to an increase in self-focused attention or objective self-awareness (Guerin & Innes, 1984, p. 41). This brought objective self-awareness, which led to comparing oneself against others or standards (Silvia & Duval, 2001, p. 231). Comparison against a standard was defined by Duval & Wicklund (1972), cited in Silvia & Duval (2001), as a mental representation of correct behavior, attitudes, and traits. All standards of “correctness” taken together will define a ‘correct’ person, and that is why this is something one will strive for (p. 231). The negative social impairments of performance explained by self-awareness theorists consist of dysfunctional high levels of effort and diversions of attention needed in the given task. If the performer notices discrepancies between task performance and performance ideals, they will be motivated to reduce them. However, when discrepancies seem impossibly large, it can result in disengagement from performance (Bond & Titus, 1983, pp. 266-267).

According to self-awareness theory, individuals appraise their personal values, abilities, and goals, often falling short of achieving them. This will lead to a cognitive state where we are motivated to improve (Guerin & Innes, 1984, p. 41). This increase in the effort to do better explains the social facilitation effect on performance for simple or well-learned tasks. However, for complex or unfamiliar tasks, it was argued that by trying too hard, we would overstep our abilities to perform well (Guerin & Innes, 1984, p. 41). Ickes et al. (1973) revealed a relationship between objective self-awareness and self-esteem, which relies on feedback. If no feedback is received or if the feedback is negative, general estimates of self-worth would decline in the presence of stimuli that heighten objective self-awareness (p. 218). It is also believed that self-focus stimuli, such as exercising in front of a mirror, could facilitate the same effect on task performance as the presence of others (Bond & Titus, 1983, p. 267).

2.3.2.4 Bond`s Self-presentational Analysis

Bond (1982) proposed a new theory, “Self-presentational analysis of social facilitation”, which suggests that the performer would be motivated to project an image of competence in front of an audience. This theory suggests that maintaining this image of competence can facilitate performance in the presence of others. Failure to do so would result in embarrassment and social impairment of performance (Bond & Titus, 1983, p. 267). This theory addresses public self-image rather than drive as the central role of behavior when others are present. If self-esteem and face are maintained during the performance, this will motivate performance. On the other hand, if the performer infers that he or she appears inept, will this lead to an acute drop in socially mediated self-regard and embarrassment (Bond, 1982, p. 1043). Self-esteem refers to feelings of satisfaction a person has about themselves, which reflects the relationship between their ideal self-image and their self-image (Silber & Tippett, 1965, p. 1017). This theory differs from the drive theory, which argues that task complexity inhibits performance if the dominant response is wrong. In contrast, the self-presentational analysis argues that complexity only influences social performance insofar as it reflects information on the performer’s task competence (Bond, 1982, p. 1044). The face will maintain undisturbed while performing simple responses with ongoing success, but continued failure on complex responses will result in a loss of esteem. These processes would therefore affect behavior independently of task complexity and lead to either social facilitation from esteem-motivated self-presentation or social inhibition due to embarrassment (Bond, 1982, p. 1044).

2.3.2.5 More recent explanations

According to Blascovich et al. (1999), social facilitation can have both enhancing and impairing effects on performance, depending on whether the individual perceives the situation as a challenge or a threat (p. 75). The biopsychological model proposes that these motivational states are accompanied by cardiovascular responses, which can be influenced by cognitive and affective mechanisms that are either learned or unlearned (Blascovich et al., 1999, p. 75). The model suggests that an individual experiences a challenge when they believe they have enough personal resources to meet the demands of the situation, while a threat arises when they feel they lack the necessary resources (Blascovich & Tomaka, 1996, pp. 11–12; Blascovich et al., 1999, p. 69). Challenge and threat arise from increased perceived demands, and with the presence of others, it is hypothesized to increase threat and consequently trigger fight-or-flight responses (van Meurs et al., 2022, p. 3).

Numerous theories attempt to clarify the reasons behind the presence's positive or negative impact on individuals. Mcfall et al. (2009) also suggested three explanations for why the potential of evaluation inhibits performance on complex tasks: 1) fear of failure leads to reduced effort, 2) fear of failure weakens processing capacity, and 3) attentional overload limits focus, which results in poor performance on tasks that require more cues than simple tasks (p. 136). Although evidence suggests that these mere presence effects involve cognitive and evaluative mechanisms such as apprehension and attention, Zajonc's classic view has remained the most common explanation (Belletier et al., 2019, pp. 260-261).

In a study conducted by Rhea et al. (2003), researchers explored the impact of coaction, competitive coaction, and audience effect on maximal weightlifting performance. Interestingly, the study found no significant differences in activation levels (drive theory) between the groups or trials. However, during interviews, participants expressed support for self-awareness theory and self-presentational analysis. For example, some participants shared that they set goals to improve their performance after seeing others lift more than them, while others admitted to feeling anxious about not lifting enough while others were watching (Rhea et al., 2003, p. 306). Although the study did not include an "alone condition," these results suggest that experienced resistance exercisers are focused on performing well and presenting themselves positively when others are present during a lifting performance.

2.4 Previous research

2.4.1 Nature of the task

Research has got attention in the field of social facilitation during motor tasks. Physical activity or movements are motor tasks that primarily rely on skeletal muscles to be performed (van Meurs et al., 2022, p. 5). Bös (1987), cited in Lämmle et al. (2010), differentiates different motor tasks with a model that distinguishes between condition-oriented abilities that are determined by energy and effort (endurance, strength, and speed, etc.) and coordination-oriented abilities that rely on the information (skill-based, coordination with time/precision pressure, etc.) (pp. 42-43). Tasks with high levels of energetic-/effort-based processes require less learning and are considered simple tasks. Perceptual-motor tasks that require higher cognitive loads tend to be considered complex tasks (van Meurs et al., 2022, pp. 5-6).

Previous research on the social facilitation effect on complex tasks has yielded inconsistent results with significant variability. According to several review articles, the mere presence of others has a relatively small impact, accounting for only 1-3% of the variance, if any effect is observed at all (Bond & Titus, 1983, p. 282; Landers et al., 1978, p. 21; Landers & McCullagh, 1976, p. 135; Strauss, 2002, p. 253). The type and complexity of the task being performed can significantly affect the impact of the presence of others. Complex or unfamiliar tasks that require coordination tend to be negatively impacted, while well-learned, simple tasks and those that require conditioning tend to improve performance (Landers & McCullagh, 1976, p. 135; Strauss, 2002, p. 251-252). When both coordination and conditioning are required, performance tends to show no difference, mainly because they outweigh each other (Strauss, 2002, p. 252). Recent research in motor tasks has shown a more evident tendency for increased performance in the presence of others, which may help clarify the effect of mere presence (van Meurs et al., 2022, p. 21).

2.4.2 Self-efficacy

According to Klehe et al. (2007), social facilitation and inhabitation share common mechanisms, including the anticipation of evaluation when in the presence of others. A critical factor that affects the performer's performance is their self-efficacy in executing the task (p. 225). Self-efficacy is concerned with judgments of how well one individual can execute courses of action required to deal with the given situations (Bandura, 1982, p. 122). Levels of self-efficacy have proven to be a decisive factor for achievement, and positive experience and mastery in the given task will facilitate increased self-confidence for future performance (Gilson et al., 2012, pp. 449–450; Wurtele, 1986, p. 295). To make accurate self-efficacy judgments, individuals need to understand the demands of the specific task. The correlation between self-efficacy and performance is lower when the task is unfamiliar.

Research in motor performance suggests that as one individual gains experience with a task over time, their performance has a greater impact on their self-efficacy than vice versa. This implies that previous performance can affect later performance (Moritz et al., 2000, p. 289). Previous research has also demonstrated that levels of self-efficacy have a positive linear effect on lower perceived exertion and on improving tolerance for exertive tasks (Hutchinson et al., 2008, pp. 467–468). Additionally, providing false or manipulated feedback has resulted in higher levels of reported self-efficacy and heavier subsequent 1RM (1 repetition maximum) lifts in the bench press (Fitzsimmons et al., 1991; Wells et al., 1993).

2.4.3 Social facilitation in strength tasks

In a study conducted by Mazzetti et al. (2000), the researchers examined the effects of a 12-week heavy resistance program on maximal strength, power, and muscular endurance. The participants were divided into two groups: one trained in direct supervision and the other trained unsupervised. The results showed that the supervised group had a higher increase in maximal strength, with a 7% increase in the bench press and an 8% increase in squats, compared to the unsupervised group (p. 1179). The researchers suggested that the difference in results could be attributed to psychological factors, such as enhanced external motivation through verbal encouragement and competitiveness in front of an audience facilitated by supervision (Mazzetti et al., 2000, p. 1181).

Rhea et al. (2003) revealed that performance among weightlifters increased in front of an audience and when competing. The study found that when weightlifters performed bench press (Life Fitness chest press machine) in front of an audience, they experienced a 13% 1RM increase (p. 305). The competitive coaction and audience effect significantly increased 1RM compared to the coaction situation. Although there were no significant differences in arousal between trials, interview responses supported self-awareness and self-presentational theory over drive theory (Rhea et al., 2003, p. 306). Rhea et al. (2003) also argued that small changes in motor tasks, as shown in the literature, could contribute to meaningful differences in strength sports such as powerlifting and weightlifting, where every kilogram counts in competitions (p. 306). Kaczmarek et al. (2022) provided supporting evidence that CrossFit athletes who performed plank (muscular endurance task) and timed up and go test plus (motor speed task) increased their performance when in front of spectators and coaction conditions compared to being alone. However, these conditions inhibited the participant's performance on tasks in the cognitive domain (pp. 80–82).

In a study conducted by Baker et al. (2011), young adults were tested on their 1RM in leg press and bench press, with and without observers of the opposite gender. The results showed that both men and women lifted more weight in the presence of observers, with no significant differences between genders when observed (Baker et al., 2011, p. 201). Women increased their 1RM bench press by 3,4 ± 0,8 lbs and leg press by 9,2 ± 3,8 lbs, while men increased their bench press by 4,2 ± 1,1 lbs and leg press by 18,8 ± 5,2 lbs when the observers were present (Baker et al., 2011, p. 201). The study required participants to have at least six weeks of resistance exercise experience before participation, which differs from similar 1RM studies in this domain. No verbal encouragement was given to the participants to keep the treatment between subjects uniform (Baker et al., 2011, p. 201).

Nickerson et al. (2021) conducted a similar study, comparing the impact of spotter sex on bench press performance during a 1RM test protocol. The study included twenty resistance-trained individuals with at least 6 months of experience who could bench at least 80% of their body mass. Both male and female spotters were used in a cross-over design, and the participant's self-reported 1RM estimation was compared with their measured 1RM (Nickerson et al., 2021, p. 2398). The study found that spotter sex did not affect strength for both women and men, but the measured 1RM among men was significantly higher than their estimated 1RM values with both male and female spotters. No differences were found among the females. Men also had significantly higher mean velocity and peak power output for the 1RM trials in the presence of a male spotter than the female spotter (Nickerson et al., 2021, p. 2399).

Sheridan et al. (2019) examined the effects of having spotters present during bench press. The study involved 12 young males with at least 12 months of experience in recreational resistance training. The participants were asked to perform two trials of 3 sets to failure at 60% of 1RM, one with two spotters present and the other without. The participant's total repetitions, total weight lifted, rate of perceived exertion, and self-efficacy were measured on both occasions. The results showed that the participants increased their total repetitions and workload by 11,2 ± 8,1% when the spotters were visible (Sheridan et al., 2019, p. 1759). The presence of spotters also significantly lowered their perceived exertion and enhanced their self-efficacy ratings. They argued that the influence of spotters on lifting performance might affect social-cognitive variables, such as increasing self-efficacy towards the specific task and lowering the perceived effort (Sheridan et al., 2019, p. 1759). The spotters did not provide verbal encouragement, as previous studies suggest will facilitate increased self-efficacy levels and improve effort and performance in strength tasks (Leitzelar et al., 2016, p. 11; McNair et al., 1996, p. 244; Wise et al., 2004, p. 28).

A recent meta-analysis by Fisher et al. (2022) reviewed the impact of long-term supervision, spanning from 4 weeks to 6 months, on resistance training. The study reviewed 12 articles that met their inclusion criteria. The participants ranged from untrained to 1-2 years of experience. The training method for both the supervised and the unsupervised groups was mainly free weights (8/12 studies). However, some studies also utilized other methods, such as resistance machines (3/12), bodyweight resistance (5/12), resistance bands (2/12), plyometric exercise (1/12), suspension training (1/12), and floor-based spinal stability exercise (1/12) (p. 12). The results of the meta-analysis showed that the supervised group had a small effect (0.28) on performance compared to the unsupervised group. The effect of strength ranged from trivial to moderate, favoring the supervised group (0.40 [95%CI = 0.06 to 0.74], and the body composition outcomes leaned towards the supervision group as well, but the effects suggested a minor impact (Fisher et al., 2022, p. 14).

2.4.4 Individual differences

A meta-analysis by Uziel (2007) on individual differences in the social facilitation literature explains that only 5-7% of the existing research has measured individual differences (pp. 584-585). Among those studies, two significant orientations toward social presence were identified: a positive orientation reflecting high self-esteem and extraversion, and a negative orientation reflecting low self-esteem and neuroticism (Uziel, 2007, p. 594). The positive orientation predisposed individuals to increase their performance in the presence of others, while the negative orientation predisposed individuals to get inhibited performance. The contribution of orientation to the prediction of performance outcome was stronger than the contribution to task complexity (Uziel, 2007, p. 594). Graydon & Murphy (1994) found that extroverted individuals tended to perform better in audience conditions than introverted individuals in table tennis. On the other hand, introverted individuals performed better without an audience (p. 266). Pederson (1970) compared low, moderate, and high test anxiety groups and revealed that individuals with moderate and high test anxiety performed better when working alone in learning and multiplication tasks. The low-test-anxious individuals performed much better when working in a group (p. 60).

2.4.4.1 Anxiety and neuroticism

Anxiety is a complex concept that involves various motivational and emotional processes resulting from a perceived threat. This threat results from a subjective evaluation of a specific situation and concerns one’s self-esteem during social situations, physical danger, performance or insecurity, and uncertainty (Schwenkmezger & Steffgen, 1989, pp. 78-79). Trait anxiety is defined as proneness to assess external events or internal stimuli in a way that can result in anxiety. It is considered a stable individual inequality in a relatively permanent personality characteristic (Spielberger, 1966, p. 13). Since trait anxiety refers to the disposition of an individual to experience anxiety and is personality-related, state anxiety refers to the instantaneous emotion of anxiety experienced in situational contexts (Elwood et al., 2012, p. 647).

Spielberger’s model suggests that internal stimuli such as thoughts, feelings, or biological needs combined with external stressors are individually considered. As a result, it will either produce anxiety or not. In this assessment, the individual’s trait anxiety is crucial for the situation’s outcome (Elwood et al., 2012, p. 647; Spielberger, 1966, p. 17). Trait anxiety and neuroticism are suggested to be synonymous interchangeably, and many researchers have been referring to those terms equally along with negative affectivity (Barlow et al., 2014, p. 352; Knowles & Olatunji, 2020, p. 5). Reactivity to stressors is proven to be twice as crucial as exposure to different stressors in explaining the relationship between distress in a person’s daily life and neuroticism. Neuroticism can predict emotional reactivity, which can be explained by ineffective coping methods when exposed to stress (Bolger & Schilling, 1991, pp. 377-378).

2.4.4.2 Anxiety differences in gender

Studies have shown that anxiety-related disorders are more common among women than men, with one in three American women experiencing an anxiety disorder during their lifetime. Rates of such disorders are 1,5-2 times higher among women (McLean et al., 2011, p. 1031), and generalized anxiety disorders are more prevalent in women than men in Scandinavian populations (Munk-Jørgensen et al., 2006, p. 1742). Research has shown that the fitness environment can have a significant impact on how individuals perceive gender relations, giving rise to three emotional experiences - gender gaze, anxiety, and dislocation tension (Li & Bao, 2022, p. 4). The reason behind this lies in the fact that commercial gyms are often considered male-dominated spaces, with deeply ingrained ideals of masculinity that can make women feel like they don't belong. There is a standard of femininity that is expected, with an emphasis on having a slender physique and wearing the right attire to be accepted in the environment. Furthermore, the gym environment can be a source of negative self-evaluation and anxiety, as individuals may fear being negatively judged by other members. Any deviations from the norm can potentially damage a woman's self-esteem and comfort (Li & Bao, 2022, p. 4).

Research conducted by Pridgeon & Grogan (2012) reported that the competitive nature and masculinity of the gym culture in commercial gyms was a primary reason for people dropping out of exercise programs. For women, social comparisons and dissatisfaction with their bodies were significant factors contributing to dropout rates (p. 397). Additionally, compared to men, women tend to experience more social physique anxiety (Chu et al., 2008, p. 9; Portman et al., 2018, p. 262). This has been identified as a potential barrier to regular physical activity, referring to a negative response to a perception that others are negatively evaluating various aspects of one’s physique (Hart et al., 1989, pp. 101–102; Portman et al., 2018, p. 257). Similarly, Judge et al. (2016) revealed that women experience higher levels of competitive trait anxiety before powerlifting competition than men (p. 2403). This study found that heightened anxiety levels were negatively correlated with personal best totals lifted in the bench press, deadlift, and squat (Judge et al., 2016, pp. 2403–2404).

White (1991) revealed that men tend to perform better than women in motor performance, regardless of whether the situation is competitive, cooperative, or non-competitive (p. 582). Competitive coaction was found to increase men’s performance scores significantly, but this effect was not observed in women (White, 1991, p. 582). In a recent study by Heinrich et al. (2021), on biathlon participants, men had faster lap times (conditioning task) but longer shooting times and less accuracy in shooting (coordination task) when an audience was present. In contrast, women had slower lap times but improved their shooting time and accuracy significantly in front of an audience (p. 4).

Previous studies on social facilitation and strength tasks have been limited, with only 5-7% of existing literature measuring individual differences. This study aims to build on Sheridan et al.'s (2019) research by measuring Trait and State anxiety in both genders, and isokinetic maximal and muscular endurance strength using an isokinetic dynamometer. I will investigate whether trait anxiety differences in genders affect strength performance with the presence of a spotter during testing. Upper and lower body strength will be measured using the squat and bench press exercises on the 1080 Quantum Syncro. The strength exercises used in this study are condition-oriented (energetically determined/effort-based), which is considered simple in the literature (Lämmle et al., 2010; van Meurs et al., 2022, pp. 5-6).

I expect an increase in performance, but to what extent and if it differs among those with higher levels of trait anxiety is unknown. Trait anxiety/neuroticism are, as previously mentioned, negatively correlated with performance in social facilitation research. However, it is unsure to what extent this applies to an experienced clinical population in strength performance. Additionally, I will compare trials with a passive spot and when the spot is supportive, which provides positive feedback. In previous research, the testing was done with a minimum of 2 observers/spotters present during testing. In this experiment, I will only use one spotter present, which in most cases is similar to a field-based scenario when asking a spotter for assistance.

2.4.5 Research question

The aim of this study is to expand upon limited research on the social facilitation phenomenon in motor tasks like weightlifting and resistance exercise. The investigation will determine if having a spotter present can enhance performance in peak and mean force production on an isokinetic dynamometer. Previous studies have explored isotonic strength measurements while inducing multiple social forces in their "mere presence" condition, but our focus will be on the presence of a single spotter/investigator. In my experiment, I will compare a passive spotter with a spotter involving interaction between the participant and the spotter present. The study will also examine the impact of gender on trait and state anxiety, as well as performance. This is a crucial aspect of social facilitation theory as it can potentially predict performance outcomes beyond just task complexity. The experiment aims to provide valuable insight into whether individual differences in anxiety can predict social facilitation or inhibition during strength tasks. Additionally, it will examine upper-body and lower-body strength performance in different repetition ranges that require distinct characteristics of muscular strength.

The following research questions were formulated:

1) Will the presence of a spotter, regardless of whether the spotter is passive or supportive, lead to improved isokinetic performance in the squat and bench press exercise?

2) Will individuals with higher levels of trait anxiety benefit less in the presence of a spotter than individuals with lower levels, and will this reflect more frequently among the female participants?

Drawing on the social facilitation theory and previous research, I hypothesize that having a spotter present will enhance strength performance for both exercises. This is because the tasks mainly require physical exertion and effort, and the participants are experienced, making the tasks relatively simple. Furthermore, as trait anxiety is inversely linked with performance and is more prevalent in females, I anticipate that the female participants will exhibit higher levels of both trait and state anxiety and be more adversely affected by the spotter conditions than the males. I further hypothesize that the presence of a spotter and the sense of being evaluated will lead to increased state anxiety scores since this is found to be arousing the performer. The supportive spotter condition is anticipated to yield the most favorable results, while the alone condition is likely to result in the poorest performance.

3.0 Method

3.1 Experimental approach

This study is an experimental study to investigate whether there is a cause-and-effect relationship between social facilitation and physical performance (Thomas et al., 2015, p. 581). This experiment consisted of 4 laboratory visits, including one familiarization session, and three subsequent experimental trials performed in a randomized cross-over manner. During the experimental trials, isokinetic peak and mean force were measured by performing 1, 2, and 10 repetitions with 0.6 and 0.3 m/s and 0.4 and 0.2 m/s in the squat and bench press exercises, respectively. The subsequent trials took place in different contexts, including the presence of a passive spotter, a supportive spotter, and performing alone. Cross-over trials were conducted, meaning participants completed multiple treatments or training methods in a randomized order. This approach allowed each participant to act as their own “control”, providing a basis for comparison (Elbourne et al., 2002, p. 140).

I used surveys to gather additional data to account for other variables. A survey is a method of collecting descriptive information or responses to specific questions researchers seek to investigate about opinions or actions in a particular population. This can be collected, among other things, in the form of questionnaires or interviews (Thomas et al., 2015, p. 491). For this study, I utilized SurveyXact to collect personal information (please refer to 4. Attachment). Additionally, I collected anxiety ratings for each participant using State-Trait Anxiety Inventory for adults (STAI-AD) with pen and paper during each trial to measure their anxiety levels and personality traits.

3.1.1 Recruitment, inclusion- and exclusion criteria

To recruit participants, I utilized posters on the walls at the Norwegian School of Sport Sciences, through social media, and physical requests on the school’s premises. The inclusion criteria for participation were having a minimum of 12 months of experience with resistance exercise and regularly using the squat and bench press exercises as compound movements in their workouts. This was to prevent the possibility of sustaining an injury throughout the testing and to eliminate confounding factors, such as rapid increases in strength due to neural adaptation. Neural factors such as the recruitment of muscle fibers can play a major in the early phase of strength training, which can result in drastic increases in skeletal muscle strength over a few days (Phillips, 2000, p. 189; Gabriel et al., 2006, p. 135). To participate, subjects also had to be injury-free for the past six months and disease-free of significant illnesses recently. Based on previous studies, Sheridan et al. (2019), with a mean strength increase of 11,2 ± 8,1% (mean ± SD) in the spotter condition, and Rhea et al. (2003) 12,9 ± 8,0% increase with the presence of an audience compared against coaction, a sample size calculation with means and standard deviations suggested 8-10 participants were needed in this study (Burmeister & Aitken, 2012, p. 273).

3.1.2 Participants

For this study, twelve recreationally trained Norwegian School of Sport Sciences students were recruited. The group consisted of six women (weight 62.4kg ± 6.4kg, height 162.8cm ± 2.4cm) and six men (weight 78.6kg ± 14kg, height 181.3cm ± 10.4cm). The average age for all participants was 22.4 (± 1.9 years). All participants were experienced in resistance exercise, with an average of 5.6 (± 1.8) years of experience, and all were familiar with both squat and bench press exercises. They also engaged in other sports in their spare time, with an average of 2.9 (± 1.6) weekly sessions (see Table 1 for an overview). Of the 12 participants, 3 were familiar with the researcher prior to testing. Resistance exercise is most popular among people aged 16-24 in the Norwegian population (Dalen, 2019). Statistics Norway also states that 90% of those with university- or college education exercise a minimum of once a week, which represents the highest percentage in the statistics among the Norwegian population (Dalen, 2019). This is the main reason I chose students at the Norwegian School of Sport Sciences since this selection can appeal to most people who use resistance training as exercise. The participants had a range of memberships and experiences in different team and individual sports, making them a diverse and experienced selection of subjects. This may contribute to more reliable results and decrease within-subject variability of performance, as they are regularly exposed to high-intensity exercise during their daily life (Hopkins et al., 2001, p. 225). Data were collected between January and April in the same gym under similar environmental conditions (room temperature).

Table 1

Participant characteristics by gender.

Variable	Men (*N* = 6)	Women (*N* = 6)	Total (*N* = 12)
Age (yr)	23.2 ± 1.7	21.7 ± 1.9	22.4 ± 1.9
Height (cm)	181.3 ± 10.4	162.8 ± 2.4	172.1 ± 12.1
Weight (kg)	78.6 ± 14.0	62.4 ± 6.4	70.5 ± 13.4
Experience (yr)	6.0 ± 1.5	5.3 ± 2.1	5.6 ± 1.8
Weekly exercise frequency (RE)	3.3 ± 1.5	3.3 ± 1.5	3.3 ± 1.4
Weekly exercise frequency (OS)	3.2 ± 1.3	2.6 ± 1.9	2.9 ± 1.6
Participation in other sports	***N* among men**	***N* among women**	***N* among total**
Football	2	-	2
Handball	-	1	1
Long distance running	2	-	2
CrossFit	-	1	1
Weightlifting	-	1	1
Powerlifting	-	1	1
Triathlon	-	1	1
Gymnastics	1	-	1
Snowboard	1	-	1

Note. RE, resistance exercise sessions; OS, other sports sessions. Values are means ± SD.

3.1.3 Deception

This study used a deceptive approach to manipulate the participants' understanding of the study's purpose. They were informed that the study aimed to assess the test-retest reliability of the 1080 Quantum system, and the shielding around the testing location was to limit distractions and ensure standardized traffic around the system during each trial. In the "alone" condition, the spotter was present but hidden from view while the participants performed. The spotter was openly present during the other trials and clarified its presence.

Deception in research means that the participants are not fully informed about the purpose of the study. In this way, valuable data can be collected that would not otherwise have been found if all factors and aspects were obvious to the participants (Skavlid, 2019). With the use of a deception approach in this experiment, I was able to prevent participants' beliefs from interfering with the results obtained. Deception is considered more inappropriate if the study involves obtaining personal or private information from the participants or if the procedure has an increased potential to expose participants to harm (Christensen, 1988, p. 672). Bortolotti & Mameli (2006) argued that the researcher should ask themselves whether the experiment can cause significant psychological harm to the participants. If this is the case, the experiment will not be morally acceptable. If the experiment does not cause significant harm, the next question is whether the degree of harm (if any) will be outweighed by the possible benefits the study provides. The experiment can be justified if the benefits outweigh the harm (p. 264). After a deceptive study design, debriefing is argued to be essential to clarify the entire purpose of the study for the participants and what benefits they are left with (insight into self, etc.) (Smith & Richardson, 1983, p. 1077). According to the research conducted by Smith & Richardson (1983), providing a debrief session can be beneficial for participants who experienced feelings of deception or betrayal during the study. This can help them feel better and ensure that their overall perception of the study is not affected negatively. The study revealed that those who received a debrief had a similar total perception after participation as those who did not experience negative feelings (Smith & Richardson, 1983, p. 1081).

The degree of deception in this study was minimal and did not pose any harm to the participants. Once data collection was complete, a debrief was conducted with all participants to fully inform them about the true nature of the experiment and the reason for the slight deception. This was done to ensure that the participants did not have a negative experience or feel misled.

This study was approved by the Norwegian Data Protection Authority (482377) and by the ethics committee of the Norwegian School of Sport Sciences (225). Before participating, all individuals provided written informed consent. Prior to the testing, a pre-exercise medical screening was conducted during the familiarization session to determine whether it was appropriate to proceed based on injury history and technique.

3.2 Procedures

3.2.1 Strength assessments

This study's primary goal is to evaluate the participants' isokinetic peak and mean force in the concentric phase at the lower extremity squat and upper body bench press compound exercises. Our investigation will examine whether having a spotter or the presence of others affects the social facilitation effect and results in significant improvements. I collected isokinetic strength outputs through 1RM, 2RM, and 10RM tests, where the participants exerted maximum effort in the respective tests at different velocities. The use of 1 repetition maximum as a measuring instrument has proven good test-retest reliability regardless of experience level, gender, and age (Grgic et al., 2020, p. 14). Although this is commonly conducted with free weights during field-based testing to measure maximal strength, isokinetic dynamometers are most used in laboratory-based settings and research (Grgic et al., 2020, p. 2; Caruso et al., 2012, p. 240). In this study, I performed the respective tests in the 1080 Quantum dynamometer in an isotonic manner.

The experiment was done on three different occasions, where participants underwent a test without a spotter, with a passive spotter, and finally with an interactive spotter. Prior to testing, participants had to attend a familiarization session 1-3 days beforehand. The testing equipment used was the 1080 Quantum Synchro (1080 Motion AB, Stockholm, Sweden), a computerized robotic engine system. This system was attached to a custom-made Smith machine, which was used for all tests. This system is highly versatile and can be used for performance training, rehabilitation, research, and testing. This apparatus measures resistance, mode, and speed levels using an electronic motor that can measure power and force throughout the eccentric and concentric phases of the movements, making it an ideal apparatus for measuring desirable movements (1080motion, n.d.). By combining two 1080 Quantum units using a Smith machine with synchro mode, one can perform various barbell exercises like squats and bench press (Boehringer & Whyte, 2019, p. 3243). Although the 1080 Quantum is relatively new in the research field, it has proven to be a precise measuring instrument and a good alternative for exercise (Bergkvist et al., 2015; Boehringer & Whyte, 2019, p. 3251; Helland et al., 2017, pp. 743-744). Its high validity makes it highly comparable to the GymAware linear position transducer, with Pearson r (0.94-1.00), %CV (2.4-8.9), and effect size (0.06-0.37), all values within appropriate limits (Boehringer & Whyte, 2019, p. 3244). All tests were conducted using gear 2 of the quantum system. The pulley that corresponds to the second gear, as provided by the manufacturer, was attached to the Smith machine bar vertically in a straight line, with the wire's output fixed in the bottom position (see Figure 1A). The system underwent calibration prior to every squat and bench press test.

Figure 1

Pictures of the system and setup

Note. 1080 Quantum system (1080Q) and Smith machine setup used in the experiment (A). Opaque cover around the 1080Q during testing (B).

The tests were conducted at approximately the same time of the day (±2 hours) with 48-72 hours resting apart. It is recommended to allow for up to 72 hours of rest before assessments for isokinetic strength testing (Abernethy et al., 1995, pp. 406-407). Research has shown that an individual's cognitive and physical performance can vary based on their chronotype, with early chronotypes (morning larks) performing better earlier in the day compared to late chronotypes (night owls), who perform better later in the day (Facer-Childs et al., 2018, p. 1). Additionally, humans tend to display higher strength values in the evening hours (16:00-20:00), and short-duration maximal performance varies between 1.7-29.4% depending on muscle group and feature. This can be explained by various factors such as endocrine function and variations in body temperature (Grgic et al., 2019, p. 456; Mirizio et al., 2020, p. 8). Therefore, it is crucial to maintain consistency in the time of day the tests are conducted for each participant to ensure standardized prerequisites.

To eliminate any sense of coaction effect or evaluation from others in the gym, all tests were conducted within a cover with opaque material. This cover was made from black fiber cloth fastened together and hung up with strips and was positioned at a height that ensured visibility from above and below was eliminated (see Figure 1B). To create a feeling of being alone in the alone condition, the participants wore 3M E-A-R earplugs to reduce noise, and a spotter was hidden from view. The tester provided clear instructions regarding weight load, velocity, and number of reps in each set. In the supportive spotter condition, participants were encouraged with feedback such as “Push!”, “Come on, push!”, “Good job” and “Let’s go!”, in addition to complements on how “easy” the set went to encourage the participants for the next attempt as done in previous research (Andreacci et al., 2002, p. 348; Weakley et al., 2020, p. 3159; Argus et al., 2011, p. 3283; Wise et al., 2004, p. 27). All verbal encouragement in the supportive spotter condition was spoken slightly louder than normal conversation volume. No verbal encouragement was given to the participants in the passive spot condition, as the spotter’s sole purpose was to be present.

3.2.2 Isokinetic testing

Isokinetic strength refers to the force that is generated by one or multiple skeletal muscles against resistance with a constant velocity throughout the range of motion (Gaines & Talbot, 1999, p. 59). In comparison to isotonic and isometric strength, this test or exercise always maintains a consistent speed throughout the entire exercise movement (Bera et al., 2007, p. 121). Isokinetic testing is commonly used to evaluate muscular strength, and it is suggested to provide more accurate values than isotonic measurements (Söderman & Lindström, 2010, p. 194). It has also been proven to estimate isotonic (free-weight) muscle strength using isokinetic testing (Lesnak et al., 2020, p. 620; Söderman & Lindström, 2010, p. 198). One unique feature of isokinetic dynamometers is their ability to adjust resistance equal to the applied muscular force at a predetermined self-selected movement speed. This provides a reduced risk of injury in rehabilitation training or testing for people suffering from ligamentous and muscular injuries, with their ability to perform movements in different practical speed ranges (Baltzopoulos & Brodie, 1989, p. 109). The most common isokinetic measurement for scientific and clinical-based work is peak torque in newton meters (PT), which refers to the highest obtained torque output produced by a muscular contraction in the joint when the current body part executes a specific movement (Kannus, 1994, p. 12). PT is proven to be highly accurate and reproducible and is considered a gold standard in isokinetic measurement when comparing clinical relevance, precision, and accuracy among the other measurement parameters (Kannus, 1994, p. 12). Another primary strength measurement for isokinetic strength testing is the 1-repetition maximum, which measures the heaviest weight that can be pushed once and is reported in kilograms (Gaines & Talbot, 1999, p. 60). This is commonly done in a pulley system, as in this experiment.

3.2.3 Bench press and squat

The bench press is a resistance exercise that has increased in popularity in terms of testing for assessing upper limb strength and treatment to improve neuromuscular performance or gain muscular strength as a multijointed exercise (Padulo et al., 2015, p. 604). This is the main exercise to measure strength in the upper body and primarily requires recruitment in the skeletal muscles consisting of the pectoralis major, triceps brachii, and deltoideus anterior, with some assistance from the medial deltoid to stabilize (Earle & Baechle, 2008, p. 343; Schick et al., 2010, p. 779). When using a machine like a Smith machine or isokinetic dynamometer, the bar is fixed in a single vertical direction, reducing the need for balance and stabilization as compared to free weights (Lander et al., 1985, p. 344; Schick et al., 2010, p. 782). The reduction in balance requirements will reduce the risk of injury while performing the exercise (Cotterman et al., 2005, p. 169). In fact, using a Smith machine may even increase reliability since it prevents the barbell from moving outside the vertical plane as the load increases, which happens to occur during free weights (Boehringer & Whyte, 2019, p. 3248; Król & Gołaś, 2017, p. 1334).

The squat exercise is essential in the strength and conditioning programs for athletes who require high levels of strength and power. This exercise also contributes to injury prevention and rehabilitation for knee injuries (Escamilla, 2001, p. 127). With the use of EMG measurements to quantify muscle recruitment in this exercise, it is revealed that this motion primarily recruits the quadriceps (vastus lateralis, vastus intermedius, vastus medialis, and rectus femoris), hamstrings (semimembranosus, semitendinosus, and biceps femoris), gluteus maximus and gastrocnemius (Earle & Baechle, 2008, p. 351; Escamilla, 2001, p. 135). Squats can be performed at different depths, including partial, parallel, and full or deep squats, with the parallel execution being the most cited in the literature. This variant indicates that the angle of the thighs is parallel to the ground (McKean, Dunn & Burkett, 2010, p. 1671). It is worth noting that free-weight squats result in higher muscle activation in biceps femoris and gastrocnemius compared to the Smith machine, likely due to higher requirements for the knee flexors to stabilize and support knee, ankle, and hip joints in this unstable environment (Schwanbeck et al., 2009, p. 2590).

3.2.4 State-Trait Anxiety Inventory

To measure individual differences in anxiety, I used the State-Trait Anxiety Inventory for Adults (STAI-AD (Form Y); Spielberger et al., 1983). The inventory contains 40 items, of which 20 measure state anxiety and 20 measure trait anxiety. Each item is rated on a four-point scale, ranging from 1 (Not at all) to 4 (Very much so) (Spielberger et al., 1983). The inventory asks individuals how they feel "right now", which measures subjective feelings of fear, activation of the nervous system, and anxious expectations (STAI-S; see Attachment 3). Furthermore, they are asked how they "generally feel", which measures individual differences in anxiety proneness (STAI-T; Spielberger, 1966, p. 17; see Attachment 2). The scores for both forms (STAI-T and STAI-S) are obtained by adding up the total scores for each item, where the score can vary from a minimum score of 20 to a maximum of 80 (Spielberger & Reheiser, 2003, p. 71). While the score for STAI-S, which measures anxiety intensity as an emotional state, is susceptible to exposure to the testing environment, the score for STAI-T has shown to be relatively stable and unaffected by the situation. STAI-T has previously shown an excellent to acceptable (.65 to .89) test-retest reliability coefficient for intervals up to 9 months (Gustafson et al., 2020, p. 7; Werner et al., in press, p. 7). Therefore, if both surveys are conducted on the same occasion, it is recommended to answer the STAI-T form after the STAI-S form (Spielberger & Reheiser, 2003, p. 71).

The STAI is widely recognized as the most cited and well-known inventory to measure trait anxiety. It has been praised for being easy to administer, score, and interpret and for being inexpensive and brief (Knowles & Olatunji, 2020, p. 5). STAI-T has good psychometric properties, with Cronbach's alpha ranging from 0.86-0.95, and has test-retest correlations from 0.73-0.86 (Nordahl et al., 2019, p. 3; Spielberger et al., 1983). Studies published between 1990-2000 showed average test-retest reliability at .88 for STAI-T, while STAI-S is lower at .70 (Barnes et al., 2002, pp. 613-614).

Moreover, the state and trait anxiety inventory scale has been validated in Norwegian samples, with a Cronbach's alpha level of 0.84 in the translated version (Haseth et al., 1990; Johansen & Haugen, 2013, p. 218). I received permission to use STAI-AD from Mind Garden, Inc (see Attachment 1), and validated items translated into Norwegian were received and approved by Pallesen et al. (2006) (see Attachment 2 & 3). I collected data for STAI-T once during the familiarization session due to its known stability, while I collected data for STAI-S inventories after the first two sets of testing on each occasion. Our goal was to ensure that the participants could comprehend the given situation and administer the inventory early on to reduce any perceived performance influence on the STAI-S score, whether positive or negative.

As part of this study, various descriptive factors were considered, such as the participant's gender, age, height, weight, experience level in resistance exercise and participation in sport(s), and the frequency of weekly workouts. The information helps to determine if the participants are accustomed to performing in front of others and if their sport primarily requires maximal strength or muscular endurance. The information was obtained through SurveyXact prior to physical participation to obtain descriptive data and create user profiles on the software used on 1080Q.

3.3 Testing protocol

Prior to the first trial, all participants were required to keep a 24-hour diet diary to roughly track their food intake. They were instructed to replicate this diet calorie-wise before each trial and to notify the researcher if there were any significant surpluses or deficits. Additionally, participants were advised to reduce their caffeine intake before the test and to avoid consuming alcohol or other drugs during the test period. Caffeine has been proven to contribute to a noticeable effect in strength-related tasks such as 1RM, isometric and isokinetic strength, as well as muscular endurance, power, and velocity in various exercises and loads (Grgic, 2021, p. 2295). This also applies to pre-workout or other ergogenic supplements such as creatine monohydrate, beta-alanine (not shown to make a significant effect if the working set is shorter than 60-240 sec.), and citrulline malate. These have been proven to have performance-enhancing effects in skeletal muscle tasks (Iraki et al., 2019, pp. 9-10). Finally, all participants were encouraged from engaging in strenuous exercise that may affect their performance.

3.3.1 Familiarization

To ensure accurate results, it is important to provide participants with a familiarization session prior to 1RM or maximal strength testing. This session will involve going through the protocol and demonstrating the exercises required for the testing. Additionally, during the familiarization session, the required depth for each participant was measured to maintain consistency throughout each trial and repetition. This is crucial as it allows the muscles to adapt to the testing, resulting in more reliable and precise data collection regardless of the participants' prior experience with resistance exercise (Dias et al., 2005, p. 42). Similarly, for isokinetic testing, multiple sessions are preferable to minimize the effect of *practice-based improvement* (PBI) (Nugent et al., 2015, pp. 212-213). Ritti-Dias et al. (2011) revealed no significant differences in maximal strength over four different 1RM sessions, while inexperienced participants required 2-3 sessions to measure an accurate maximal strength (p. 1421). As isokinetic dynamometers are unfamiliar to most people, participants should receive some training and experience the test device to reduce potential anxiety and achieve reliable torque tracings (Brown & Weir, 2001, p. 11; Kannus, 1994, p. 14).

Both exercises were performed according to NSCA's exercise technique manual guidelines (National Strength and Conditioning Association, 2008, pp. 26-28 & 78-79). Specifically, they performed parallel squats, ensuring that the angle of their thighs was parallel to the floor. To maintain consistency, a rubber band was attached to a movable rack and used as a guide for each participant's depth during the squats, which was measured and marked with sports tape individually. The concentric phase began when the elastic band moved, as seen in the mirror, placed 1.5 meters in front of the participants. This allowed for visual feedback during the squats, inspired by Augustsson & Svantesson's (2013) work. The same mirror (160 cm x 40 cm) was used on all occasions (see Figure 2A). Each participant self-selected their stance width, which was marked with sports tape to standardize the test sessions. Participants had the option to wear footwear or go barefoot, as they preferred, provided they stuck to the same shoes throughout the testing. However, wrist wraps, lifting belts, and knee sleeves were not allowed.

During the bench press exercise, participants were required to lie down on their backs with their buttocks touching the bench. They had to place both feet flat on the floor and grip the bar with their hands in a pronated grip. The width of the grip was determined by each participant's preference but remained consistent throughout each set. Upon the investigator's instruction, participants had to lower the bar in a controlled manner (2-second count) until the bar touched the chest. The session comprised 4 sets with varying repetitions (10, 5, 2-3, and 1) and resistance levels (60-100% of their internal resistance of total testing weight). I also tested whether participants could complete repetitions with their bodyweight (0.8 and 0.5 of their BW in bench press and 1.0 and 0.8 in squats for men and women) at the velocities used in the test to assess potential changes in loads. The aim of this session purpose was to make participants more familiar with the 1080 quantum system and to help them understand the resistance and feel of the exercises when executed in a Smith machine. This session was conducted 1-3 days before the commencement of testing.

3.3.2 Warm-up

Isokinetic testing requires a warm-up procedure, but the reasons for choosing a specific method are often unclear. There seems to be a lack of explanation for choosing one warm-up method over another (Boehringer & Whyte, 2019, p. 3243; Keating & Matyas, 1996, p. 876; Mawdsley & Knapik, 1982, p. 171). To address this issue, the warm-up protocol prior to the testing of these two compound movements in the Smith machine was inspired and modified by the NSCA's test manual for 1RM with a slight increase in intensity due to adapting the musculature to the acute effort requested later (Beachle et al., 2008, p. 396; Brown & Weir, 2001, p. 14; Perrin, 1986, p. 320). Participants first performed a general aerobic warm-up on a treadmill or ergometer bike for 5-10 minutes (Borgs scale: 10-12), followed by a specific warm-up on the Smith machine connected to the 1080 Quantum for squat and bench press, respectively.

To prepare for the testing, participants completed three warm-up sets. The first set had 10 repetitions with 60% of their testing resistance plus the system's external weight (26kg) (1 or 0.8 and 0.8 or 0.5 of BW based on gender and exercise). After 2-3 minutes of passive rest, a second set is followed with 5 repetitions at 80%. After another 2-3 minutes of rest, they performed the third and final warm-up set with 2-3 repetitions at 90% of the internal test weight (see Table 2). In addition to the linear increase in resistance, the participants were told to gradually increase their effort during the repetitions as the warm-up sets got heavier and the repetition range decreased. Participants with such a low body weight that they were supposed only to use the Smith bar during testing (26 kg) were assisted by rubber bands attached to the bar during the warm-up sets to follow the same protocol (see Figure 2B). After an extended resting period of 4-5 minutes, the first testing set began. No form of stretching was included in the protocol due to contradicting evidence in use prior to when explosive and maximal force is necessary (Behm & Chaouachi, 2011, p. 2647; Beedle et al., 2008, pp. 1841-1842; Wilcox et al., 2006, pp. 265-266). Those participants who felt it necessary to execute self-made warm-up routines in the form of dynamic stretching prior to performing squats or bench presses were allowed to do so as they remained doing so before each trial.

Table 2

Warm-up protocol before testing.

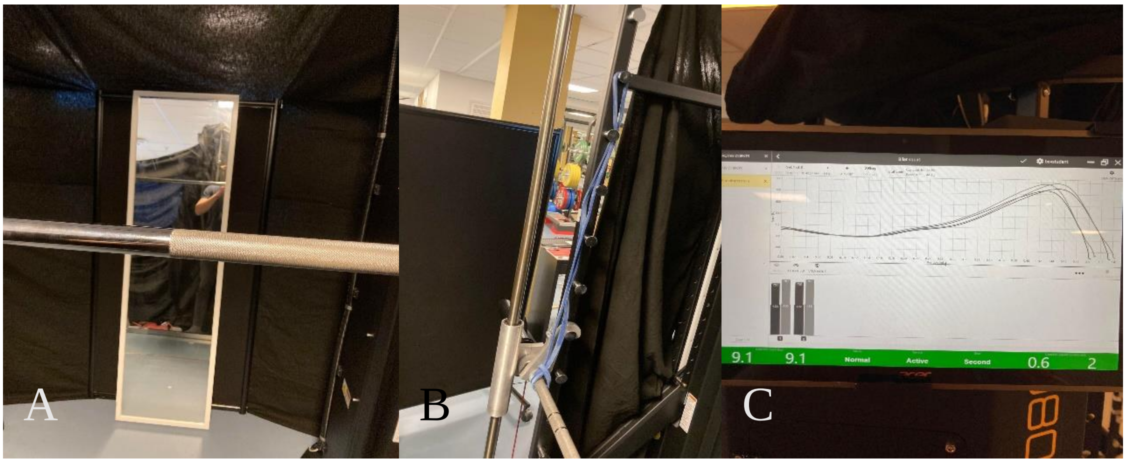
General aerobic warm-up	Treadmill or ergometer bike for 5-10 min. (Borg scale 10-12)	
	Repetitions and Resistance	**Velocity in phases**
Specific warm-up on 1080 Quantum synchro – **Squat** Testing weight = 1.0x body weight men, 0.8x body weight women	1 set with 10 repetitions with 60% of added internal weight (in addition to 26 kg external)	0.6 m/s concentric, 2.0 m/s eccentric
	2-3-minute rest	
	1 set with 5 repetitions with 80% of added internal weight (in addition to 26 kg external)	0.6 m/s concentric, 2.0 m/s eccentric
	2-3-minute rest	
	1 set with 2-3 repetitions with 90% of added internal weight (in addition to 26 kg external)	0.6 m/s concentric, 2.0 m/s eccentric
	4-5-minute rest before testing begins	
	Squat testing...	
Specific warm-up on 1080 Quantum synchro – **Bench press** Testing weight = 0.8x body weight men, 0.5x body weight women	1 set with 10 repetitions with 60% of added internal weight (in addition to 26 kg external)	0.5 m/s concentric, 2.0 m/s eccentric
	2-3-minute rest	
	1 set with 5 repetitions with 80% of added internal weight (in addition to 26 kg external)	0.5 m/s concentric, 2.0 m/s eccentric
	2-3-minute rest	
	1 set with 2-3 repetitions with 90% of added internal weight (in addition to 26 kg external)	0.5 m/s concentric, 2.0 m/s eccentric
	4-5-minute rest before testing begins	
	Bench press testing…	

3.3.3 Testing

During the test, squats were performed with a concentric velocity at 0.6 and 0.3 m/s, while bench press was done at 0.4 and 0.2 m/s. Both exercises had an eccentric velocity set at 2.0 m/s. Two separate attempts were made for each velocity, with the highest velocity being done in a 2RM manner and the lowest in 1RM. A final set of 10 repetitions with maximum effort was performed at the lowest velocity, with a 25% decrease in internal resistance on the bar (see Table 3). According to the National Strength and Conditioning Association's training load chart based on Landers (1984), athletes or experienced lifters should be capable of completing 10 repetitions at 75% of their max intensity (National Strength and Conditioning Association, 2012). Participants who needed to take off more than the external load on the system (26kg) were assisted by a rubber band. Between each set, 3-4 minutes of passive rest were given, which has been proven sufficient for reducing fatigue and underestimation of maximal strength in isokinetic testing, and when acute expression of muscular power is needed (Parcell et al., 2002, p. 1020; Willardson, 2006, p. 981; Freitas de Salles et al., 2009, p. 770).

Figure 2

Mirror, assisting rubber band, and computer screens used during testing.



Note. The 160 cm x 40 cm mirror used during testing (A). Rubber bands that were used when the external load was heavier than protocol for participants with low body weight (B). Tablet screen showing force (N) produced during the previous set (C).

In this study, a single spotter was assigned to the Smith machine mounted on the 1080 Quantum, and the same spotter remained throughout all trials for all participants. This differs from previous studies by Sheridan et al. (2019) and Baker et al. (2011), which involved two spotters and a principal investigator during the “present” condition. The participants were not able to see the visual feedback curve on the computer screens during their sets as it may affect their optimal isokinetic strength performance and maximum torque (Campenella et al., 2000, p. 4; Baltzopoulos et al., 1991, p. 140; Figoni & Morris, 1984, p. 196). However, they were free to view the test results between sets since one cannot physically see how much weight is lifted during each set, as in isotonic testing (see Figure 2C). All participants were informed about changes in load and velocity before conducting each set in the protocol, although load knowledge during testing has not been shown to have a notable effect on strength performance or RPE (Beaudoin et al., 2018, p. 517; Snarr et al., 2021, p. 2124). The subject’s age, body weight, height, and gender were registered in the dynamometer system before testing, so the estimated measurements considered those criteria.

Table 3

Test protocol during each trial.

Squat test (**1.0x body weight** for men, **0.8x body weight** for women)	
Repetitions	**Velocity in phases**
2 repetitions with maximal effort	0.6 m/s concentric, 2.0 m/s eccentric
3-4-minute rest	
2 repetitions with maximal effort	0.6 m/s concentric, 2.0 m/s eccentric
3-4-minute rest	
1 repetition with maximal effort	0.3 m/s concentric, 2.0 m/s eccentric
3-4-minute rest	
1 repetition with maximal effort	0.3 m/s concentric, 2.0 m/s eccentric
3-4-minute rest	
10 repetitions with maximal effort ~75% of the internal testing weight	0,3 m/s concentric, 2.0 m/s eccentric
Bench press test (**0.8x body weight** for men, **0.5x body weight** for women)	
Repetitions	**Velocity in phases**
2 repetitions with maximal effort	0.4 m/s concentric, 2.0 m/s eccentric
3-4-minute rest	
2 repetitions with maximal effort	0.4 m/s concentric, 2.0 m/s eccentric
3-4-minute rest	
1 repetition with maximal effort	0.2 m/s concentric, 2.0 m/s eccentric
3-4-minute rest	

1 repetition with maximal effort	0.2 m/s concentric, 2.0 m/s eccentric
3-4-minute rest	
10 repetitions with maximal effort ~75% of the internal testing weight	0,2 m/s concentric, 2.0 m/s eccentric

3.4 Statistical analyses

All data were analyzed for normality by exploring standardized residuals in each variable. These were determined by comparing the mean with the median and analyzing the histogram, q-q plot, and Shapiro Wilk. To determine the main effects of passive and supportive spot's peak force, mean force, and distance for 2RM, 1RM, and 10RM in both squats and the bench press, I used repeated-measures analysis of variance (ANOVA). Additionally, I conducted another repeated measures ANOVA with the same variables, but trial order independent of condition to measure for learning effects. ANOVA was used to determine STAI-S between trials, while an independent-sample *t*-test was used to determine STAI-T between genders. To correct Type I errors, I adjusted by estimating the marginal means and comparing the main effects with Bonferroni in post hoc pairwise comparisons. The Bonferroni correction method is commonly utilized to compare various groups, investigate the correlation between variables, analyze multiple endpoints in an experiment, or adjust family-wise error rates in multiple comparisons. Family-wise error correction is performed when a limited number of related group means are compared after a post hoc analysis. This is done by dividing the planned error rate by the number of tests being run (Armstrong, 2014, p. 502; Emerson, 2020, p. 78). Statistical significance was set at $p \leq 0.05$, which means coincidences can allow type I error less than 5% of the time (Lieber, 1990, p. 305). Effect sizes were determined using partial eta squared η_p^2 for ANOVA and Cohen's *d* for independent-sample *t*-test, with 95% confidence intervals (CIs). Effect sizes can be categorized as small, medium, or large, whereas small is defined as (η_p^2 = 0.01), medium (η_p^2 = 0.06) and large (η_p^2 = 0.14) effects (Lakens, 2013, p. 7). All procedures were conducted using SPSS version 29 for Windows (IBM Inc., Portsmouth, United Kingdom). The 2RM was obtained by averaging the peak and mean force produced during the two repetitions made in one of the two attempts for each trial, while the 10RM was obtained by averaging the peak and mean force during the ten repetitions made (or by the total repetitions made) for each trial. The mean force and peak force mean differences will be presented in Newton (N).

4.0 Results

In this chapter, I will present anxiety scores obtained from STAI-S and STAI-T surveys and categorize the strength measurements based on the level of muscular capacity required. The 2RM and 1RM tests demand acute muscular force production with maximal effort, which will be classified as maximal strength. On the other hand, the 10RM test requires more endurance, which will be categorized as muscular endurance in this chapter. Moreover, I will also provide a comparison between genders and discuss any learning effects observed.

4.1 Anxiety scores

Trait-Anxiety among all participants was measured at *M* = 33.3 (*SD* = 6.9), while the females had a slightly higher score (*M* = 36.2, *SD* = 7.9) compared to the male participants, who had a score of *M* = 30.3 (*SD* = 4.6). The trait-anxiety scores between genders were insignificant; *t* (8) = -1.56, *p* = .158, *d* = -0.9). Interestingly, the state-anxiety scores did not vary significantly between the situations where they had a spotter and where they did not. The state-anxiety scores in PS (Passive Spotter) and SS (Supportive Spotter) conditions were identical to the NS (No Spotter). Interestingly, NS revealed the highest score of *M* = 29.9 (*SD* = 5.1), but all comparisons were insignificant *F* (2, 22) = 0.225, *p* = .800, and no correlation between state and trait anxiety was observed. Although the female participants did not show any differences in their state-anxiety scores across conditions, the male participants exhibited some inclinations in the distinction between the NS condition and PS *F* (2, 10) = 2.650, *p* = .119, η_p^2 = .346, with a difference of (*M* = 3.7, 95% CI [-1.9, 9.2], *p* = .198, η_p^2 = .559). No gender-specific discrepancies were noticed in state anxiety for condition or between trial orders. Nevertheless, the female participants revealed noteworthy changes between the first and second trials *F* (2, 10) = 2.187, *p* = .163, η_p^2 = .304, with a difference of (*M* = 2.5, 95% CI [-0.3, 5.3], *p* = .080, η_p^2 = .692).

Table 4

Mean (±SD) of psychophysiological variables.

	Condition		
	Supportive spotter	Passive spotter	No spotter
State Anxiety Males	28.7 ± 4.9	27.3 ± 4.5	31.0 ± 4.6
State Anxiety Females	29.8 ± 6.7	30.7 ± 8.1	28.8 ± 5.9
Total	29.3 ± 5.6	29.0 ± 6.5	29.9 ± 5.2
Sig.	1.0	1.0	

Note. Total STAI-S scores during each trial. Significance is reported by the difference between trials (comparing No spotter) for STAI-S.

4.2 Maximal strength

Table 5 shows all statistical effects computed in the Anova for the different variables in the strength measuring, while Table 6 displays the mean and standard deviations for all trials, along with post hoc comparisons using Bonferroni between conditions. In the text, I will mainly focus on the significant findings. Results from the 2RM tests indicate that there were no significant differences between trials in peak force or mean force in squats. However, both spotter conditions received higher mean scores compared to NS. SS received the highest increase in both peak force and mean force compared to NS. Similar to these results, the bench press 2RM testing did not show any significant strength improvements in 2RM between trials. The SS condition did receive the bests score between conditions, while NS received the lowest.

The performance of 1RM squat for both peak F (1.316, 14.478) = 11.462, p = .003, $\eta_p^2 = .510$ and mean force F (2, 22) = 6.821, p = .005, $\eta_p^2 = .383$ showed a significant overall effect between conditions (see Figure 3 & Figure 4 for visual presentation). The results revealed an increase of (M = 223.6 N, 95% CI [143.3, 303.8], p = .001, η_p^2 = .881) in peak force, and (M = 94.1 N, 95% CI [31.3, 156.9], p = 0.004, η_p^2 = .713) in mean force in the SS condition compared to NS. Additionally, the SS condition led to a significant increase in peak force compared to PS (M = 175.8 N, 95% CI [30.9, 320.8], p = .017, η_p^2 = .881). However, PS did not show any significant increase in either peak force or mean force in the 1RM squats when compared to the NS condition but did receive higher means.

In the bench press, significant effects were observed between trials for peak force F (2,

20) = 3.534, p = .048, $\eta_p^2 = .261$. SS compared to PS increased (M = 42.8 N, 95% CI [1.0, 84.6, p = .044, η_p^2 = .468). No significant differences were observed between conditions in mean force. PS compared to NS, did not show any differences, while SS received minor improvements.

4.3 Muscular endurance

During the 10RM squat tests, there was a significant increase in both peak F (2, 22) = 6.258, p = .007, $\eta_p^2 = .363$ and mean force F (2, 22) = 5.481, p = .012, $\eta_p^2 = .333$ between conditions (see Figure 5 & Figure 6 for visual presentation). The SS revealed on average a peak force increase (M = 166.5 N, 95% CI [51.5, 281.5], p = .005, η_p^2 = .616) and mean force increase (M = 81.3 N, 95% CI [10.3, 152.2], p = .024, η_p^2 = .512) compared to NS. While there was also a noticeable increase in peak and mean force differences between PS and NS, these differences were not significant (M = 78.3 N, 95% CI [-73.2, 229.9], p = .519) and M = 28.8 N, 95% CI [-45.5, 103.1], p = .891). There was no significant difference between PS and SS conditions, but there was a noticeable increase in both peak and mean force. In all SS trials for the 10RM, ten repetitions were made, but one participant (N=1) completed eight repetitions during the first trial with PS and nine repetitions when alone in the second trial. Ten repetitions were completed by the other participants in PS and NS.

During the 10RM bench press tests, significant overall effects were observed between trials F (2, 20) = 3.499, p = .050, $\eta_p^2 = .259$ for peak force, but no significant results were observed in test conditions. No significant effects were between trials for mean force F (2, 20) = 3.162, p = .064, $\eta_p^2 = .240$. However, both PS and SS received higher mean scores in peak and mean force compared to NS, while the SS received the most evident results. No differences were observed between PS and SS conditions. Even though some participants did not complete ten repetitions during all trials (N=3), the total number of repetitions made during all trials was identical for all three conditions.

4.4 Comparison between genders

4.4.1 Two repetitions maximum

The study results indicate that there were no significant differences in 2RM for squats between the genders in any of the conditions. However, male participants had a higher percentage increase in peak and mean force when subjected to PS and SS conditions. The males experienced a 9.3% increase in peak force in the SS condition, whereas the females experienced a 7.4% increase. In terms of mean force, the males experienced a 7.4% increase, while the females only had a 3.6% increase. Compared to NS, PS resulted in a 6.1% in peak and a 5.4% increase in mean force for the males. The females experienced a 5.4% increase in peak force and a 2.7% increase in mean force.

During the 2RM bench press tests, male participants did not display any significant differences in peak or mean force among the various conditions. The SS condition resulted in a 5% increase in peak force and a 2.6% increase in mean force compared to the alone condition. On the other hand, the PS condition only showed a 1.8% increase in peak force and no change in mean force. For female participants, no significant effects were revealed, and a small to negligible increase in peak force and mean force for both spotter conditions were observed. In the SS condition, peak force and mean force increased by 1.7% and 1.8%, respectively, compared to performing alone. Moreover, the PS condition facilitated only a 1.2% increase in peak force and a 0.8% increase in mean force.

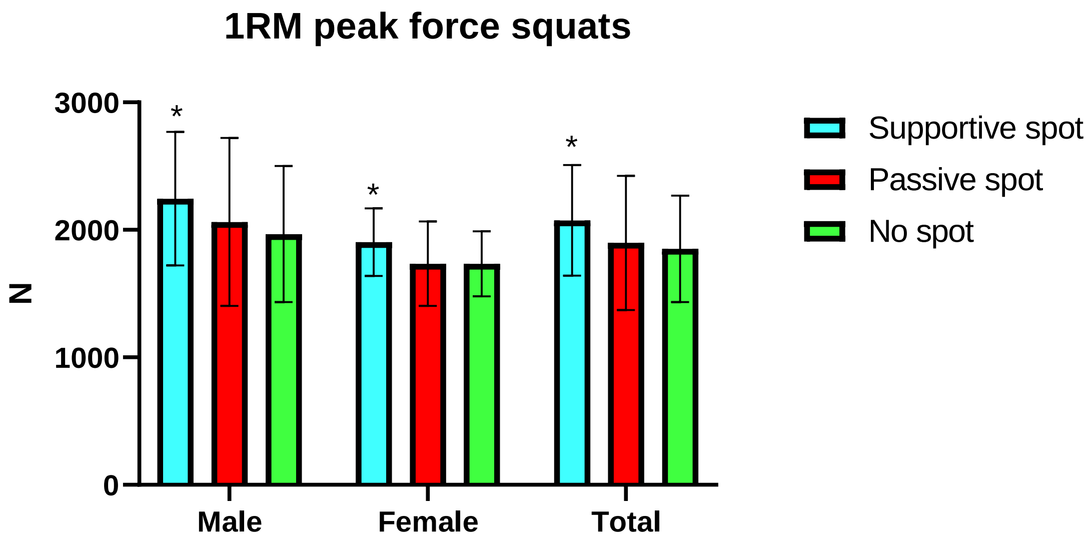
4.4.2 One repetition maximum

During the 1RM squat test, male participants experienced a significant effect in peak force F (2, 10) = 4.490, p = .041, $\eta_p^2 = .473$, and a non-significant practical effect in mean force F (2, 10) = 3.549, p = .068, $\eta_p^2 = .415$ between conditions (see Figure 3 & Figure 4 for visual presentation). In the SS condition, the male participants received a 14.1% peak force increase (M = 277.0 N, 95% CI [134.9, 419.1], p = .003, η_p^2 = .921) and a 9.4% mean force increase (M = 123.7 N, 95% CI [-23.5, 270.9], p = .094, η_p^2 = .678) compared to NS. No significant performance increases were revealed in the PS condition compared to NS. Either way, PS received a 4.8% increase in peak force and a 6.6% increase in mean force.

The females did also experience significant improvements in both peak *F* (2, 10) = 16.944, *p* = .001, η_p^2 = .772 and mean force *F* (2, 10) = 11.566, *p* = .003, η_p^2 = .698 in SS compared to both NS and PS conditions. They experienced a 9.8% increase in peak force (*M* = 170.2 N, 95% CI [69.9, 270.5], *p* = .006, η_p^2 = .935) and a 6.2% increase in mean force (*M* = 64.5, 95% CI [29.8, 99.2], *p* = .004, η_p^2 = .911) in SS compared when they were alone. In the SS condition compared to PS, they experienced a 9.8% increase in peak force (*M* = 169.5 N, 95% CI [65.4, 273.6], *p* = .007, η_p^2 = .935) and a 5.7% increase in mean force (*M* = 60.2 N, 95% CI [2.9, 117.4], *p* = .041, η_p^2 = .911). No differences were found in either peak force or mean force between the PS and NS conditions.

Figure 3

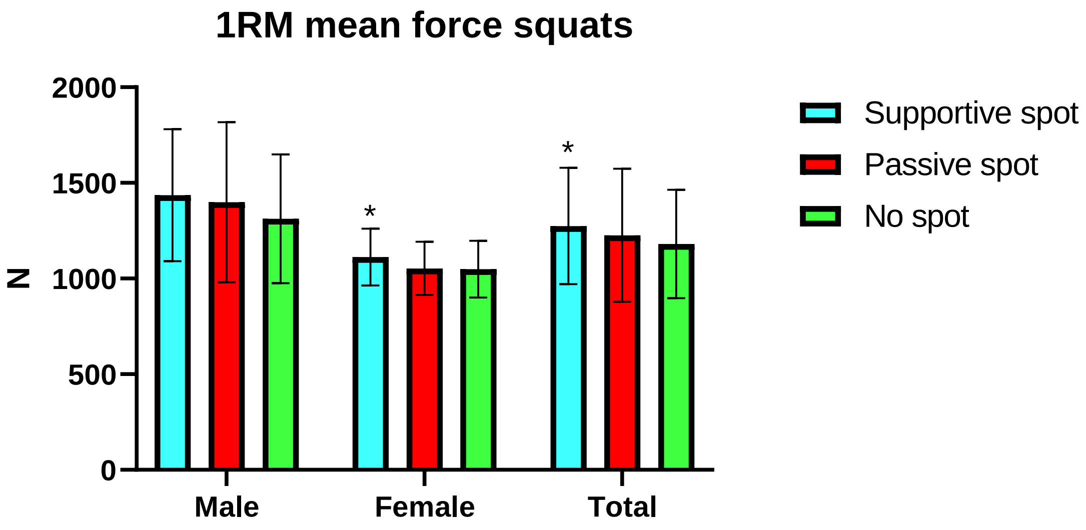
Peak force for 1RM in squats among conditions.



Note. Mean (SD) 1RM peak force performance for squats between conditions. *=significantly higher force production between conditions (p < .05).

Figure 4

Mean force for 1RM in squats among conditions.



Note. Mean (SD) 1RM mean force performance for squats between conditions. *=significantly higher force production between conditions (p < .05).

In the 1RM bench press tests, male participants experienced no significant overall effects in either peak force or mean force between trials. Although they experienced a significant 6.1% peak force increase in SS (M = 63.4 N, 95% CI [8.4, 118.4], p = .031, η_p^2 = .850), and a 3.2% increase in mean force compared to PS. The SS condition resulted in a 4.1% increase in peak force and a 3.1% increase in mean force compared to the NS. Interestingly, they received a decrease in peak force by 1.9% and no difference in mean force in the PS condition compared to NS.

No differences in conditions were observed for the female participants on either peak force or mean force. The female participants were also experiencing a slight decrease of -1.2% in bench press peak force during the PS but revealed no differences in mean force when compared to NS. In the SS condition, they experienced a 2.4% increase in peak force and a 1.7% increase in mean force compared to the alone condition.

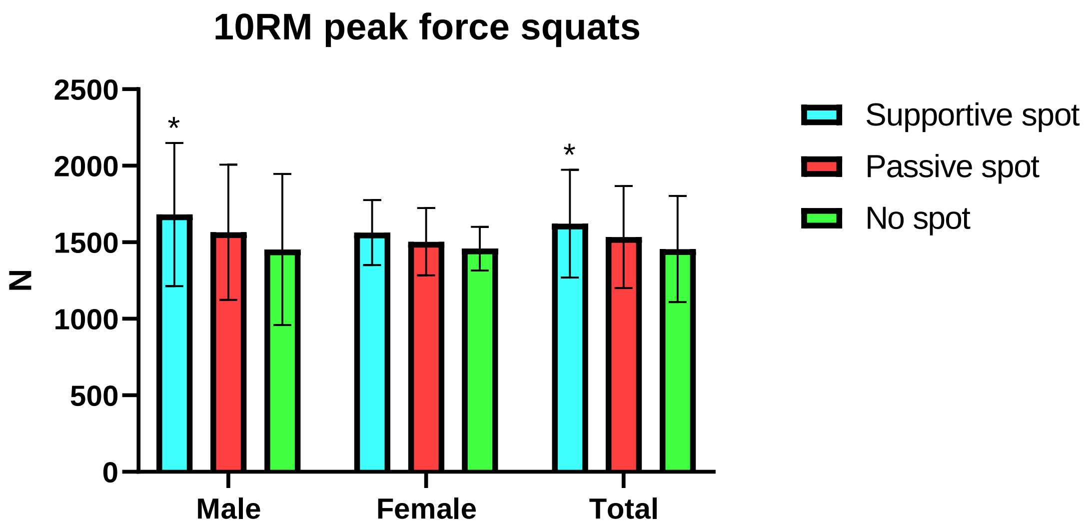
4.4.3 Ten repetitions maximum

The male participants experienced significant improvements in peak force F (2, 10) = 4.149, p = .049, $\eta_p^2 = .453$ but non-significant improvements in mean force F (2, 10) = 3.435, p = .073, $\eta_p^2 = .407$ in the 10RM squats testing between conditions (see Figure 5 & Figure 6 for visual presentation). The SS condition compared to NS, there was a significant increase of 15.7% in peak force (M = 228.3 N, 95% CI [36.5, 420.2], p = .025, η_p^2 = .780) and an apparent 11.3% increase in mean force (M = 120.2 N, 95% CI [-35.0, 275.3], p = .123, η_p^2 = .607). For the PS condition, they experienced a non-significant increase of 7.7% in peak force and a 5.3% increase in mean force compared to the NS.

On the other hand, the females did not experience any significant changes between trials in peak force F (2, 10) = 2.036, p = .181, $\eta_p^2 = .289$ or in mean force F (2, 10) = 3.910, p = .056, $\eta_p^2 = .439$ during 10RM in squats. In the SS condition, the females showed a 7.2% increase in peak force and a 4.7% increase in mean force compared to the NS, which was only half of the performance increase the male participants received during the same task. They also experienced approximately half of the effect in PS as well, with a 3.1% increase in peak force and no differences in mean force in the PS condition compared to NS.

Figure 5

Peak force for 10RM in squats among conditions.



Note. Mean (SD) 10RM peak force performance for squats between conditions. *=significantly higher force production between conditions (p < .05).

Figure 6

Mean force for 10RM in squats among conditions.

Note. Mean (SD) 10RM mean force performance for squats between conditions. *=significantly higher force production between conditions (p < .05).

During the bench press 10RM, male participants experienced no significant differences in peak force between trials F (2, 8) = 3.003, p = .106, $\eta_p^2 = .429$ but revealed significant effects in mean force F (2, 8) = 4.562, p = .048, $\eta_p^2 = .533$. They experienced an increase of 6.1% in peak force and a 6.2% increase in mean force when performing with PS compared to performing alone. However, when performing with SS, the increase in performance was lower, with only a 3.6% increase in peak force and a 4.3% increase in mean force compared to the NS condition.

Female participants received no significant changes between trials during the 10RM for bench press, for either peak force or mean force. When performing with the SS, the female participants had an equal increase in peak force as male participants, with an increase of 3.3%. The increase in mean force was almost half the increase of males, with only a 2.3% increase compared to NS. They revealed only a minimal increase of 1.7% in peak force and no differences in mean force when performing with the PS compared to performing alone.

4.4 Learning effects between trials

It was investigated whether bias between trials occurred due to learning effects, by examining peak and mean force in the order of the tests. No differences were found in any bench press peak or mean variables during any of the repetition ranges between trial one and two or one and three. However, in squats, there were significant differences in 2RM peak values between trial one vs. two and one vs. three F (1.222, 13.446) = 7.972, p = .011, $\eta_p^2 = .420$. The differences observed between trial one and two were reportedly (M = 146.2 N, 95% CI [7.9, 284.5], p = .038, η_p^2 = .458) and between trial one and three (M = 225.3 N, 95% CI [9.6, 440.9], p = .040).

Additionally, mean force values for the same tests also showed a significant effect between trials F (2, 22) = 5.423, p = .012, η_p^2 = .330 and revealed noteworthy changes for trial one vs. two (M = 42.0 N, 95% CI [-14.4, 98.4], p = .179, η_p^2 = .385) and one vs. three (M = 71.8 N, 95% CI [-5.4, 148.9], p = .071). Other noticeable improvements between trials included 1RM mean force F (2, 22) = 3.147, p = .063, $\eta_p^2 = .222$ between trial one and three with an increase of (M = 70.8 N, 95% CI [-27.3, 169.0], p = .200, η_p^2

= .275), and 10RM mean force F (2, 22) = 1.861, p = .179, $\eta_p^2 = .145$ between trial one and two (M = 43.9 N, 95% CI [-17.7, 105.5], p = .209, η_p^2 = .272) during squats.

Table 5

Statistical summary table for anxiety and strength measurement outcome between conditions using ANOVA Tests of Within-subject effects.

Measure	Effect	df, error	F	p	η_p^2
STAI-S					
State anxiety	Time	2, 22	1.22	.316	.099
	Condition Total	2, 22	0.23	.800	.020
	Condition Male	2, 10	2.65	.119	.346
	Condition female	2, 10	0.36	.704	.068
Squats					
2RM Peak	Time	1.22, 13.45	7.97	.011*	.420
	Condition Total	2, 22	2.60	.097	.191
	Condition Male	2, 10	1.06	.383	.175
	Condition Female	1.09, 5.43	1.5	.275	.231
2RM Mean	Time	2, 22	5.42	.012*	.330
	Condition Total	2, 22	3.02	.069	.216
	Condition Male	2, 10	2.03	.183	.288
	Condition Female	2,10	0.95	.419	.160
1RM Peak	Time	2, 22	1.54	.237	.123
	Condition Total	1.32, 14.48	11.46	.003*	.510
	Condition Male	2, 10	4.49	.041*	.473
	Condition Female	2, 10	16.94	.001**	.772
1RM Mean	Time	2, 22	3.15	.063	.222
	Condition Total	2, 22	6.82	.005*	.383
	Condition Male	2, 10	3.55	.068	.415
	Condition Female	2, 10	11.57	.003*	.698
10RM Peak	Time	2, 22	1.21	.316	.099
	Condition Total	2, 22	6.26	.007*	.363
	Condition Male	2, 10	4.15	.049*	.453
	Condition Female	2, 10	2.04	.181	.289
10RM Mean	Time	2, 22	1.86	.179	.145
	Condition Total	2, 22	5.48	.012*	.333
	Condition Male	2, 10	3.44	.073	.407
	Condition Female	2, 10	3.91	.056	.439
Bench press					

2RM Peak	Time	2, 20	0.51	.610	.048
	Condition Total	2, 20	2.6	.099	.206
	Condition Male	2, 8	3.11	.100	.438
	Condition Female	2, 10	0.27	.769	.051
2RM Mean	Time	1.26, 12.58	0.23	.693	.023
	Condition Total	2, 20	3.56	.048*	.263
	Condition Male	2, 8	2.75	.123	.407
	Condition Female	2, 10	0.99	.405	.166
1RM Peak	Time	2, 20	0.05	.949	.005
	Condition Total	2, 20	3.53	.048*	.261
	Condition Male	2, 8	3.11	.100	.437
	Condition Female	2, 10	0.72	.509	.126
1RM Mean	Time	1.29, 12.86	0.82	.412	.076
	Condition Total	2, 20	2.22	.134	.182
	Condition Male	2, 8	1.58	.264	.283
	Condition Female	2, 10	0.59	.574	.105
10RM Peak	Time	2, 20	0.18	.838	.018
	Condition Total	2, 20	3.5	.050*	.259
	Condition Male	2, 8	3.0	.106	.429
	Condition Female	2, 10	1.5	.270	.230
10RM Mean	Time	2, 20	0.19	.831	.018
	Condition Total	2, 20	3.16	.064	.240
	Condition Male	2, 8	4.56	.048*	.533
	Condition Female	2, 10	1.58	.254	.240

Note. *= significance of <.05, **= significance of <.001. Time represents differences between trial order (learning effects), while condition represents differences between spotter conditions.

Table 6

Respective strength measurements in peak and mean force are presented in mean and standard deviation.

Variable	Condition										
	Supportive spotter				Passive spotter				No spotter		
	Males	Females	Total	Sig.	Males	Females	Total	Sig.	Males	Females	Total
Squat 2RM Peak	1978.7 ± 536.4	1503.8 ± 218.8	1741.3 ± 462.6	.227	1921.7 ± 763.0	1462.3 ± 181.8	1692.0 ± 580.7	.437	1811.0 ± 582.3	1369.3 ± 174.5	1590.2 ± 470.3
Squat 2 RM Mean	1210.2 ± 311.1	852.2 ± 118.4	1031.2 ± 292.1	.223	1188.2 ± 386.0	845.3 ± 119.7	1016.8 ± 326.1	.177	1127.2 ± 331.0	823.0 ± 126.6	975.1 ± 286.9
Squat 2 RM Distance	.50	.48	.49	.554	.50	.47	.48	1.0	.49	.46	.48
Squat 1RM Peak	2244.0 ± 523.6	1904.0 ± 265.5	2074.0 ± 433.8	.001* **	2061.8 ± 658.8	1734.5 ± 331.8	1898.2 ± 525.9	1.0	1967.0 ± 534.3	1733.8 ± 255.2	1850.4 ± 417.3
Squat 1RM Mean	1436.0 ± 345.5	1113.2 ± 148.4	1274.6 ± 304.5	.004*	1399.0 ± 417.7	1053.0 ± 139.4	1226.0 ± 347.6	.559	1312.3 ± 336.6	1048.7 ± 148.0	1180.5 ± 283.6
Squat 1RM Distance	.50	.47	.49	1.0	.51	.46	.48	1.0	.52	.46	.49
Squat 10RM Peak	1682.0 ± 467.8	1563.3 ± 213.0	1622.7 ± 352.1	.005*	1565.0 ± 441.5	1504.0 ± 219.7	1534.5 ± 334.0	.519	1453.7 ± 493.4	1458.7 ± 142.7	1456.2 ± 346.3
Squat 10RM Mean	1179.8 ± 325.2	947.0 ± 111.2	1063.4 ± 261.7	.024*	1116.3 ± 295.9	905.7 ± 97.8	1011.0 ± 237.2	.891	1059.7 ± 307.2	904.7 ± 111.6	982.2 ± 234.8
Squat 10RM Distance	.48	.45	.46	.842	.48	.45	.47	1.0	.49	.45	.47
Bench press 2RM Peak	929.4 ± 188.7	584.2 ± 93.2	741.1 ± 226.0	.253	901.2 ± 172.3	580.8 ± 94.8	726.5 ± 210.6	.770	885.2 ± 172.9	574.2 ± 94.8	715.5 ± 207.0
Bench press 2RM Mean	785.8 ± 164.0	448.0 ± 56.9	601.5 ± 208.6	.224	766.6 ± 152.0	443.8 ± 53.5	590.5 ± 197.7	1.0	765.8 ± 150.3	440.2 ± 58.6	588.2 ± 199.2
Bench press 2RM Distance	.37	.38	.37	.018*(.005)**	.35	.37	.36	1.0	.36	.36	.36
Bench press 1RM Peak	1095.4 ± 214.7	726.3 ± 101.0	894.1 ± 246.3	.486 (.044)**	1032.0 ± 225.6	700.7 ± 111.9	851.3 ± 237.8	1.0	1052.2 ± 229.9	709.5 ± 124.7	865.3 ± 246.9
Bench press 1RM Mean	878.2 ± 177.0	543.7 ± 72.8	695.7 ± 213.8	.548	850.8 ± 181.2	536.8 ± 82.0	679.5 ± 208.3	1.0	852.2 ± 176.5	534.8 ± 82.0	679.1 ± 208.1
Bench press 1RM Distance	.37	.36	.37	.121 (.008)**	.36	.35	.35	1.0	.36	.35	.36
Bench press 10RM Peak	805.0 ± 152.6	575.0 ± 67.8	679.5 ± 161.4	.140	824.2 ± 160.6	566.0 ± 83.2	683.4 ± 178.8	.154	777.2 ± 140.6	556.5 ± 92.7	656.8 ± 159.6
Bench press 10RM Mean	688.6 ± 127.9	472.7 ± 52.5	570.8 ± 143.6	.078	701.0 ± 130.0	461.3 ± 65.0	570.3 ± 156.6	.295	660.4 ± 131.0	462.3 ± 73.1	552.4 ± 142.3
Bench press 10RM Distance	.35	.34	.34	.245 (.022)**	.33	.33	.33	1.0	.34	.33	.33

Note. *= significance between supportive spot and no spot. **= Significance between supportive spot and passive spot. Values are mean ± SD. Peak and Mean are presented in Newton (N), Distance in meters. Significance between conditions was conducted using Pairwise Comparison with Bonferroni correction.

5.0 Discussion

The aim of this study was to examine whether the presence of a spotter has an impact on muscular performance in terms of maximal strength and muscular endurance. By measuring state and trait anxiety among the participants using State-Trait Anxiety Inventory for Adults (STAI-AD (Form Y); Spielberger et al., 1983), my aim was to investigate whether both genders and individuals with higher anxiety scores would benefit in performance by having a spotter present. Supportive spotter condition was included as a condition outside the social facilitation domain (mere presence/passive spot) to compare behavioural approaches different spotters may have.

5.1 Anxiety scores

Although the research sample was homogeneous, the female participants displayed a higher tendency towards trait anxiety than the male participants. These results align with previous research that suggests women generally score higher on measures of trait anxiety (McLean & Anderson, 2009, p. 499; Knowles & Olatunji, 2020, p. 2). State anxiety levels were not affected by the presence of a spotter, which contradicts expectations. Ferreira & Murray (1983) received significantly higher state anxiety among the group performing in front of an audience than the group without an audience (p. 16). On the other hand, Rhea et al. (2003) observed no differences in arousal states among coaction, audience, and competitive coaction trials, which could support this finding, even though the coaction effect was eliminated in our experiment. Leitzelar et al. (2016) also found no differences in state anxiety between those performing in front of an audience versus those who did not have an audience while completing a handgrip squeezing task (pp. 11-12).

Further, Rykert et al. (2017) hypothesized that athletes would experience less stressful stimuli (state anxiety) when relying upon the safety extended via spotters (p. 38). Contrary to their hypothesis, no differences were found in cognitive or somatic anxiety scores between those with one spotter versus three spotters (Rykert et al., 2017, p. 40). It is worth noting that in my recent study, male participants tended to feel more anxious when they were alone, likely due to the feeling of safety. Conversely, the negative impact of others on state anxiety during a task may not be as noticeable during strength tasks, as performing a heavy lift alone may be perceived as more threatening than doing so with an audience. Interestingly, female participants showed the lowest state anxiety mean score during the alone condition, which may be linked to their trait anxiety and smaller improvements in performance during the spotter conditions. (Judge et al., 2016, pp. 2403–2404; Pederson, 1970, p. 60; Uziel, 2007, p. 594).

5.2 Maximal strength

The study did not reveal any significant results in the 2RM tests for either the squat or bench press exercises, regardless of the condition. However, it was observed that having a passive or supportive spotter resulted in higher mean scores for both peak and mean force compared to the alone condition. Due to the high variability among the participants, no significant conclusion could be drawn. The 2RM test was conducted at the highest concentric speeds of 0.6 m/s for squats and 0.4 m/s for bench press. It has been suggested that strength testing in isokinetic dynamometers has lower reliability in briefer movement speeds (Abernethy et al., 1995, p. 409; Hopkins et al., 2001, p. 228). The maximum force is obtained when the velocity is small, which arguably creates higher variation during faster velocities (Zatsiorsky et al., 2021, pp. 25-26; Taber et al., 2016, p. 72). This was also observed among the participants during testing. Within-subject variability was noticeable, and some participants showed high variability among repetitions. The average peak and mean force were estimated to decrease overall variation by combining the two repetitions in the best set instead of one repetition in the respective velocity.

The supportive spotter condition showed the best results among the different conditions, as predicted from previous research (Landers & McCullagh, 1976, p. 126; McNair et al., 1996, p. 244; Wise et al., 2004, p. 28). Among male participants, the supportive spotter condition resulted in a 9.3% increase in peak force and a 7.4% increase in mean force during squats, while female participants experienced a 7.4% increase in peak force and a 3.6% increase in mean force. In comparison, the passive spotter insignificantly increased peak and mean force by 6.1% and 5.4% for males and 5.4% in peak, and 2.7% in mean force for females. During the 2RM for bench press, verbal encouragement doubled the effect of the spotter role for male participants, while minor improvements were observed for both spotter trials for the female participants compared to the alone condition. According to Argus et al. (2011), larger muscle groups are likely to experience more improvement with feedback than smaller muscles. They also proposed that untrained individuals who do not regularly engage the same percentage of muscles during exercise may benefit more from psychological strategies and feedback than well-trained individuals (Argus et al., 2011, p. 3285). Since my study involved highly experienced individuals, it is possible that the potential for improvement with feedback may be limited, and the improvements in quadriceps strength are likely to be more noticeable than those in the pectoralis.

During the 1RM tests, both genders exhibited significant improvements in squats for both peak and mean force (except for the male's mean force, $p = .094$) when accompanied by a supportive spotter, in contrast to the alone condition. The male subjects displayed greater improvements in percentages for both variables, with a 14.1% ($p = .003$) increase in peak force and a 9.4% increase in mean force, compared to the female participants, who received a 9.8% ($p = .006$) increase in peak and a 6.2% ($p = .004$) increase in mean force. There were no significant results for the PS condition for either variable, but male participants revealed some noteworthy mean differences compared to the NS. They experienced a 4.8% increase in peak force and a 6.6% increase in mean force, while the females only experienced a 0.04% improvement in peak force and a 0.4% increase in mean force when squatting in front of PS compared to the NS. However, the bench press showed a negative effect on PS compared to NS. Both male and female participants had a decrease in peak force, with the male participants experiencing a 1.9% decrease and the females receiving a 1.2% decrease. In terms of mean force, the male participants experienced a slight 0.2% decrease, whereas the female participants experienced a marginal improvement of 0.4%.

Although none of the passive spotter findings in the maximal strength tests were significant, the mean differences between conditions tend to support the findings of Baker et al. (2011), who had a bigger sample size ($N = 49$). The observer trial showed a 1RM increase of 5% ($p = .002$) in leg press and a 2.5% ($p = .001$) increase in the bench press for the male participants, while the female participants showed a 4.5% ($p = .025$) increase in leg press and 5% ($p = .001$) increase in the bench press. These percentages indicate that the presence of an observer in the experiment only facilitated a 2.5-5% effect, and female participants experienced a higher increase in performance compared to males in front of passive observers (Baker et al., 2011, pp. 201-202). The inclusion criteria for their study required at least six weeks of resistance training experience, which is less than most studies in this domain. One can argue that because of this criterion, the experience level in that sample was of high variance compared to similar studies (some participants had only weeks of experience, while others had years), reducing the observed effect and potentially enhancing the learning effects and systematic bias (Atkinson & Nevill, 1998, p. 217).

In contrast, Nickerson et al. (2021) revealed that while comparing spotter gender and the gender performing the 1RM lifts in the bench press, male participants had significantly higher measured 1RM values when a female (6.1%, $p < 0.05$) or male (5.7%, $p < 0.05$) spotter was present, compared to their estimated values. Among the female participants, no differences were observed with female (3.7%, $p = .26$) or male (3.3%, $p = .27$) spotters (Nickerson et al., 2021, p. 2399). Despite the comparison against self-reported 1RM estimations, the male participants received the best effect by having a spotter present.

Rhea et al. (2003) revealed a much higher increase for both males and females in their experiment. When comparing the impact of audience trial and coaction, male participants experienced a 14.2% increase in kilogram, while females experienced an 11.8% increase in kilogram in a chest press machine. This difference could be attributed to the number of people observing the performer during the test. In Baker et al. (2011), three people were present during the observation condition, while Rhea et al. (2003) had fifteen people in the audience condition. Nickerson et al. (2021) used one male or female spotter (depending on the condition) and another male principal investigator present during all trials. However, this present experiment had only one person present as a spotter while eliminating the coaction effect and reducing the evaluation sources to the one spotter present. Overall, these findings suggest that males tend to show greater improvements in maximal strength tasks than females.

5.3 Muscular endurance

During the 10RM testing for the squat exercise, male participants experienced a significant increase in peak force (15.7%, $p = .025$) and a non-significant increase in mean force (11.3%, $p = .123$) when in the SS condition compared to being alone. Female participants, on the other hand, showed no significant increases for either peak or mean force when in the SS condition. However, the mean differences showed an increase of 7.2% in peak force and 4.7% in mean force compared to the NS. In the PS condition, no significant differences in performance were found for either peak or mean force among both genders. Compared to being alone, the mean differences for the PS condition were a 7.7% increase in peak and a 5.3% increase in mean force for the male participants, while a 3.1% increase in peak and a 0.1% increase in mean force were recorded for the females. These findings suggest that the experiment facilitated twice the effect for male participants compared to females, regardless of the spotter condition. It could be argued that if this study only included males, the results may have been more evident and closer to significant by the degree of differences in enhancements. Previous research within social facilitation has demonstrated better performance among male participants in motor tasks (White, 1991, p. 582; Heinrich et al., 2021, p. 4), but few studies have mentioned such a gender-interaction effect within social presence (van Meurs et al., 2022, p. 21).

Results from the bench press exercise indicate that there were no significant differences observed when comparing the alone condition to the PS or SS for both male and female participants. In the PS, male participants demonstrated the highest performance, with a 6.1% increase in peak force and a 6.2% increase in mean force compared to the NS. In the SS condition, there was a mean difference increase of 3.6% in peak force and a 4.3% increase in mean force. Female participants showed a 1.7% increase in peak force compared to NS but a 0.2% decrease in mean force. In the SS, females demonstrated an equal increase in peak force as the male participants, with a 3.3% increase but only a 2.3% increase in mean force, which is half the effect observed for male participants. The p-value for the SS versus NS in 10RM in the bench press for both genders combined was at .140 in peak force, while almost significant in mean force with a p-value of .078.

The results of this study were quite different from those of Sheridan et al. (2019), despite the similarity in methodology and sample size. While Sheridan et al. (2019) observed a significant improvement in muscular endurance performance in the bench press (60% of 1RM to failure for three sets), with an average increase of 11.2% compared to alone condition, our study only showed a 6.1% increase in peak force and a 6.2% increase in mean force in male participants in the passive spotter condition. The females, on the other hand, only received a minor effect in peak force and a decrease in mean force, which greatly reduced the total effect observed in the group. One reason for the difference in results between our study and Sheridan et al. (2019) could be due to the use of isokinetic resistance, which was not used in their study. In this experiment, participants had prior experience with resistance exercise (averaging 5.6 years) but were unfamiliar with the isokinetic dynamometer, which may have affected the impact of the spotter's presence and the results. Additionally, our study utilized a slow predetermined velocity, resulting in a constant limb motion and equal counterforce, unlike a gravity-loaded system which would result in increased acceleration (Moffroid et al., 1969, p. 735; Osternig, 1986, p. 51). The level of complexity or familiarity with the task can be a significant predictor of performance within social facilitation theory and may have limited the performance improvements for our recreational trained participants.

During the bench press and squat exercises, the supportive spotter condition showed the most promising results in 10RM compared to all other conditions. This outcome was expected, as previous studies have demonstrated that verbal encouragement during and specific feedback on prior performance can increase self-efficacy levels, effort, and performance in the bench press (Andreacci et al., 2002, p. 350; Wise et al., 2004, p. 28; Weakley et al., 2020, p. 3161). Although male participants experienced the highest mean difference increase in the PS condition among the 10RM in the bench press, Sheridan et al. (2019, p. 1759) also found that self-efficacy levels could improve with two passive spotters present, which may explain the performance increase in the two different spotter conditions, in addition to a desire to be perceived as competent in the task when the spotter was present.

5.4 Methodological considerations

To conduct this research, I used a method inspired by a previous study (Sheridan et al., 2019) that involved deceiving participants during the data collection process. This experimental design ensured that the true nature of the study remained concealed, allowing changes between trials to occur naturally without arousing suspicion in participants. Isokinetic strength measurements were collected on three different occasions, each with a different manipulation - a passive spotter, a supportive spotter, and a trial where the spotter was absent for both the squat and the bench press exercise. To eliminate the coaction effect and the sense of being evaluated by others, all trials were conducted within an opaque cover. Additionally, a mirror was placed in front of participants when they performed squats to distinguish between the presence and absence of the spotter during the test. Trait anxiety levels were measured among all participants prior to the intervention and collected state anxiety during each trial.

This study is among the few employing deceptions as a method in social facilitation research and anxiety comparisons between genders and conditions. This weightlifting experiment within social facilitation is the first to incorporate an isokinetic dynamometer to measure muscle strength in both upper and lower body regions. Specifically, the trials focused on the squat and bench press exercises, while ensuring that the velocity variable was regulated during each repetition. This study is the first of its kind that I am aware of, focused on measuring individual differences in muscular strength performance while considering both trait and state anxiety. The primary goal was to compare participant behaviors under different spotter conditions (SS and PS) with an alone condition. According to the feedback given after the debrief, none of the participants suspected deception or were able to figure out the true nature of the experiment. Although some noticed changes between trials, the spotter kept the information hidden until after data collection.

5.4.1 Environmental factors

Previous studies have shown that listening to preferred music during exercise can enhance muscular endurance, boost motivation, and lead to greater effort, increased velocities, and power outputs in explosive muscular performance (Ballmann, 2021, p. 11; Bartolomei et al., 2015, p. 718). The research was conducted at a public fitness center located within the Norwegian School of Sports Sciences, and the presence or absence of music during each session could not be accounted for but was noted down just in case. However, it should be noted that this study was limited by the inability to differentiate between the potential effects of music and the social facilitation effect of having a spotter present. In the “alone” condition, earplugs were used to reduce or eliminate the surrounding sound, including the sound of music, potentially widening the gaps in results even further.

To create a feeling of solitude during experiments, covering up the testing site and providing earplugs to block out noise may not be enough to prevent participants from feeling evaluated. According to van Meurs et al. (2022), it is challenging to create an experimental situation where participants do not feel observed or evaluated (p. 22). To establish a genuine mere presence effect in social facilitation research, it is crucial to minimize the physical and evaluative presence of the experimenter (van Meurs et al., 2022, p. 22). In their meta-analysis, it was found that the social facilitation effect was reduced by 50% when the experimenter was reported in the same room as the subjects during the alone conditions. In my research, the spotter was theoretically in the same room as the participants but remained outside the opaque cover while the participants performed during NS. As far as I am aware, none of the individuals involved in the intervention had any suspicions of deceit. However, Ortmann & Hertwig (2002) has pointed out that suspicion among participants could impact their behavior in psychology (p. 119).

The use of a mirror for visual feedback in the current study may have influenced performance during each trial, according to Duval and Wicklund's self-awareness theory. This theory suggests that the presence of others and mirrors may be two factors that influence a person to become objectively self-aware and lead to self-evaluation (Bond & Titus, 1983, s. 267; Chmelo et al., 2009, p. 1068). Previous research has shown that using a mirror can lead to better performance in a coordination motor task than having someone else present (Innes &

Gordon, 1985, p. 482). This implies that when the spotter was present, two sources of stimuli within social facilitation could affect performance. In contrast, one source of stimuli was present when they performed in the alone condition. Some of the participants found it more convenient to stay focused during their repetitions in the alone condition when they used earplugs and felt isolated from others. These individuals were accustomed to working out with a headset and preferred to keep their thoughts to themselves during resistance exercises. According to a study by Katula & McAuley (2001), highly active females who exercised in front of mirrors experienced a significant increase in self-efficacy from baseline to post-exercise (p. 324). However, a study by Katula et al. (1998), cited in Katula & McAuley (2001), showed that women reported lower exercise self-efficacy than men only in the mirror condition, indicating a significant gender interaction effect (p. 320). The difference in results could be attributed to the fact that females who received discrepancies in efficacy levels were less fit and less confident in their ability to exercise (Katula & McAuley, 2001, p. 325).

Tests were conducted within an opaque cover to eliminate the coaction effect caused by other individuals exercising simultaneously. This coaction could potentially lead to further facilitation in real-world scenarios where individuals exercise in public spaces, such as a gym (Kaczmarek et al., 2022, p. 7; Landers & McCullagh, 1976, pp. 131-132; van Meurs et al., 2022, pp. 16-17). It was anticipated that there would be comparable restrictions in improvements when only one spotter was present. Previous studies (Sheridan et al., 2019; Baker et al., 2011) involved two passive spotters and a project manager in the audience, exposing participants to multiple individuals. In another study by Rhea et al. (2003), 15 passive individuals were present in the audience trial during testing. McCullagh & Landers (1976) found that the activation level of participants increased linearly as more observers were present (pp. 1069-1070), which may explain the noticeable results in our experiments.

The social impact theory, which is similar to social facilitation in several aspects, posits that the number of social forces (number of individuals present) will increase the emotional and behavioral impact of the target individual (Latané, 1981, pp. 343-344). This theory suggests that the amount of impact experienced in a social setting should be a multiplicative function of the number of individuals (sources) present, the strength (importance, prior relationship, etc., to the source), and the immediacy (closeness in space or proximity) (p. 344). People have a common urge to be seen in a positive light by others, and they engage in impression management tactics to achieve this, like buying specific items or pretending to impress others (Argo et al., 2005, p. 208). As a result, if more individuals were present, there would likely be a higher inclination to regulate these impressions and a stronger desire to be viewed as competent in the strength exercises performed in this study.

5.4.2 Surveys and Inventories

In this study, the widely recognized, user-friendly, and reliable State-Trait Anxiety Inventory for Adults (STAI-AD) was utilized (Knowles & Olatunji, 2020, p. 5; Spielberger et al., 1983). The inventory was particularly relevant to this study as it has been translated and validated in Norwegian, making it suitable for the participants (Haseth et al., 1990; Pallesen et al., 2006). The primary objective was to assess the level of trait anxiety among the participants by utilizing the STAI-T. Individual differences were considered for those who underwent the strength tests. In addition, state anxiety was also included as a variable since it was part of the same inventory. This variable was crucial in comparing the different conditions based on situational anxiety.

As the SurveyXact items and STAI-AD inventories were self-administered and not anonymous to the researcher, there may be some inaccuracies or biases in the responses. People tend to exaggerate normative behavior that is socially constructed as something positive such as exercising and eating healthy and may misreport traits and other socially undesirable attitudes (Brenner & DeLamater, 2016, p. 347; Tourangeau & Yan, 2007, pp. 876-877). This could lead participants to underreport their relation to anxious traits and states, presenting themselves as pleased individuals who do not struggle in their everyday lives.

During the STAI-S test, participants were asked to refer to their feelings and experiences from a few seconds ago. However, this can lead to a degree of recall bias, where respondents answer based on their past events and emotions (Althubaiti, 2016, p. 213). Another factor that can affect the results is the possibility of participants remembering their previous answers when researchers use repeated survey questions. It is generally believed that respondents aim to provide consistent responses (Cialdini et al., 1995, pp. 324-325; Schwarz et al., 2020, p. 326). Other sources of errors, such as misinterpreting test items, mismarking answers, or changes in participants’ feelings or opinions during the time between trials, could also affect the reliability of these measurements (Drost, 2011, pp. 108 & 112). It may be worthwhile to contemplate the timing of administering state-anxiety inventories, either after the trials or towards the end, since evidence has indicated that the presence of an audience can significantly affect the results (Ferreira & Murray, 1983, p. 17).

5.4.3 Strength Assessment and Protocol

In this study, an isokinetic dynamometer (1080 Quantum) was utilized as it is believed to yield more precise results than isotonic measurement and is commonly recognized as the gold standard for assessing muscle strength (Dvir & Müller, 2020, p. 587; Söderman & Lindström, 2010, p. 194). According to Boehringer & Whyte's (2019) research, the 1080 Quantum system is a reliable tool for measuring kinematic and kinetic variables across various relative loads. They found that it provides accurate measures of peak and mean velocity, force, and power between 30-70% of 1RM, but its accuracy decreases when dealing with heavier loads (p. 3251). In my research, I utilized lighter loads that were determined by gender and exercise, with a focus on velocity as a challenging factor in strength measurement. For the heaviest participants in this study, this may be an essential consideration. Boehringer & Whyte (2019, p. 3251) noted that they mainly used first gear but had to switch to second gear for some subjects, which could explain the reduced reliability at higher loads. To ensure consistency, I used the second gear for all trials in both exercises and the pulley associated with the second gear provided by the manufacturer during the entire experiment.

Squat and bench press exercises are widely recognized as effective multi-joint exercises for assessing muscular strength and are commonly included in resistance exercise programs (Escamilla, 2001, p. 127; Padulo et al., 2015, p. 604). The purpose was to select exercises that are familiar to most recreational fitness enthusiasts and involve both the upper and lower body. Although these exercises can be complex and advanced when done free weighted, they were relatively simple for the experienced individuals in our sample when performed using a Smith machine during this experiment. This could potentially minimize the risk of injury during testing and prevent any learning effects or within-subject variability caused by neural adaptations and techniques (Gabriel et al., 2006, p. 135; Hopkins et al., 2001, p. 225).

The results of the strength measurements among some subjects show a linear performance increase, which is attributed to practice-based improvements. The 2-repetition maximum for squats significantly increased in both peak and mean force due to learning effects. However, the low reliability of this type of testing may be due to the unnatural movement involved, resulting in a higher coefficient of variation compared to other performance tests (Bridgeman et al., 2016, p. 3264; Hopkins et al., 2001, p. 223). The main sources of error in measuring performance occur mainly in systematic bias, such as fatigue and learning effects during testing (Atkinson & Nevill, 1998, p. 217). When participants are tested in multiple trials, there will always be variations in the mean value between trials. This within-subject variation in maximum power or force output changes due to physical and mental state and high variability in strength scores can make it challenging to observe significant performance findings (Hopkins, 2000, pp. 2-3; Mawdsley & Knapik, 1982, p. 172). Systematic changes occur as learning effects, where participants benefit from previous trial experiences, which could depend on motivation or effort, with reference from previous executions. It is clear evidence that learning effects occur between the first two trials of a test (Bridgeman et al., 2016, p. 3264; Hopkins, 2000, p. 5; Hopkins et al., 2001, pp. 230-231). It is suggested that practice-based improvements caused by dynamometers may be reduced if the intervals between trials are lengthened or by including more familiarisation trials (Atkinson & Nevill, 1998, p. 224; Dirnberger et al., 2013, p. 201; Mawdsley & Knapik, 1982, p. 171). Since this experiment standardized various parameters such as range of motion, participants' positioning, predetermined the velocity, and used the same loads during each trial, this enabled valid data interpretation and reduced sources of random error (Atkinson & Nevill, 1998, p. 220; Brown & Weir, 2001, pp. 10-14; Dvir & Müller, 2020, p. 600).

The individual who served as the researcher and spotter in this study lacked professional experience in isokinetic strength testing, which may have impacted the testing protocol during the interventions. To develop the protocol, the researcher drew inspiration from previous studies and literature rather than personal experience in maximal muscular strength testing using isokinetic dynamometers. Prior to the study, the spotter spent several sessions practicing with the 1080 Quantum device and gained personal experience with each exercise using this system. It is possible that a higher spotter effect occurred in both passive and supportive trials if the spotter/supervisor had a higher level of "status" or credibility with the participants. According to Bond & Titus (1983), performers tend to have higher drive levels in the presence of evaluative others, particularly experts who can increase drive more strongly than peers (pp. 277-278). Hopkins et al. (2001) argued that differences in respect and trust between researchers and participants could account for some data reliability variation between otherwise similar studies (p. 230). Previous research in this domain has been conducted by certified strength and conditioning specialists (Coutts et al., 2004; Enoksen et al., 2013; Fisher et al., 2022; Mazzetti et al., 2000; Nickerson et al., 2021; Ratamess et al., 2008). While the spotter possessed several years of education in sport science and a certification in personal training, the person spotting could still appear as a student in this experiment. Self-efficacy levels and performance have been proven to increase if the supervisor giving verbal feedback informs lifters of their qualifications (Wise et al., 2004, p. 28).

During testing, a weakness that was observed was the participants' inconsistent effort levels. It appeared that their motivation to surpass their previous scores affected whether they achieved a higher score or not. One possible reason for this could be that the load used in the isokinetic testing was lighter than in isotonic testing, and while the load was informed to the participants, it was not visible to them. Even though studies by Beaudoin et al. (2018) and Snarr et al. (2021) found no significant differences between trials where subjects were aware of the load versus trials where they were not while bench pressing, this may affect the focus and arousal state for the participants prior to the attempts. The results may have been different if another protocol had been utilized by estimating a 1RM for each participant during the familiarization session. Using heavier loads during testing based on their maximal capacity rather than body weight may have increased uncertainty among the participants regarding their ability to succeed. This could have had a greater impact on performance by the provided safety and the presence of the spotter, which have been proven to enhance self-efficacy levels and the desire to be perceived as competent (Rhea et al., 2003, p. 306; Sheridan et al., 2019, p. 1759; Wise et al., 2004, p. 28).
Furthermore, the warm-up for this experiment was based on isotonic strength testing (Beachle et al., 2008, p. 396) with a slightly more focus on intensity because of the standardization in load (based on body weight) and isokinetic tests (Brown & Weir, 2001, p. 14; Osternig, 1986, p. 67; Perrin, 1986, p. 320). Because of this, the warm-up conducted in this experiment has not been validated for testing in the 1080 Quantum. However, Keating & Matyas (1996, p. 876) argued that no perfect warm-up procedure has been identified that can guarantee safety and stability in test results. It is possible to argue that in this recent study, the bench press exhibited lower improvements in a socially facilitated environment when compared to squats because of exercise order. This may be attributed to the fact that the bench press was conducted after five maximal effort sets of squats, which could have caused peripheral and mental fatigue prior to the bench press test. This fatigue can impede the central motor drive, restrict force production, increase the perception of effort, and affect motivation or the willingness to maintain effort (Tornero-Aguilera et al., 2022, pp. 11-12). When comparing outcomes with previous studies conducting bench press in this domain (Rhea et al., 2003; Sheridan et al., 2019), this should be considered.

Furthermore, pacing strategies may also account for the variation in measurements on maximum force among participants. Halperin et al. (2014a, b) discovered that men and women tend to resort to pacing strategies during repeated maximal voluntary contractions. Participants may use these strategies to conserve energy throughout the endpoint, regardless of instructions, to produce maximum force at every repetition. According to the research conducted by Halperin et al. (2014a, b), participants who were tricked into performing only six repetitions before being asked to do a few more until they reached 12 repetitions, exerted more force during the initial six repetitions compared to those who were asked to complete 12 repetitions outright. The two studies mentioned collected 2.3% and 3% higher average force production in the deception trials than in the control trials (Halperin et al., 2014a, p. 738; Halperin et al., 2014b, pp. 1416-1417). This suggests that even when instructed to produce maximum force at every repetition, participants tend to hold back their effort and use pacing strategies when required to perform multiple maximal repetitions in a set.

5.4.4 Sample

The participants selected in this study were recreational trained students from the Norwegian School of Sport Sciences. In Norway, individuals between the ages of 16 and 24 and those who have received a university or college education are the target group that engages in resistance exercises the most (Dalen, 2019). This sample was selected to serve as a representative of most individuals who exercise in a gym and possess experience with the tasks involved in the intervention. In accordance with social facilitation theory, it is crucial with familiar or simple tasks to enhance performance by the mere presence of others and their experience level is beneficial for reliability in data collection on strength measurements. This approach can ensure that the data collected are more accurate than those with less experience (Hopkins et al., 2001, p. 225; Ritti-Dias et al., 2011, p. 1421; Strauss, 2002, p. 249; van Meurs et al., 2022, p. 20).

It should be noted that the experiment conducted had a small sample size, which could be considered a limitation. Previous studies by Sheridan et al. (2019) showed a mean strength increase of 11.2 ± 8.1% (mean ± SD) in the spotter condition, and Rhea et al. (2003) showed a 12.9 ± 8.0% increase in the presence of an audience compared to coaction. A sample size calculation based on means and standard deviations indicated that 8-10 participants would be sufficient for this experiment (Burmeister & Aitken, 2012, p. 273). However, the data collected in this study did not yield the expected outcome. Despite the limited number of participants in this study, each participant underwent four laboratory visits and completed identical strength tests under three distinct conditions. The study collected both peak and mean force data from three different repetition ranges with varying loads and velocities for both the squat and bench press exercises. Thus, the behavioral change and performance observed were valuable information rather than the person. In fact, the number of observations/trials was quite substantial compared to the sample size of participants. In general, a smaller sample of participants with more observations/trials within subjects is often a preferable approach (Tambling & Anderson, 2013, p. 405). To obtain more similar results to the study conducted by Sheridan et al. (2019), it may be argued that a more homogeneous sample of male participants could have been tested. However, it should be noted that the male participants in this study demonstrated overall better improvements than the females, who were the only gender represented in their study with the same sample size (N=12).

In addition, it was impossible to oversee the participants' actions during their rest periods (spare time) except to urge them to take certain precautions, such as refraining from consuming alcohol or engaging in strenuous activities. As the participants were highly active individuals, the data collected could be influenced by other types of physical activity or poor rest intervals between trials. Nonetheless, all assigned participants successfully completed the experiment without any dropouts (N=12). Only one trial, which involved bench press with a "passive spotter" condition, was omitted due to a minor elbow injury. This incident occurred outside the project during the spare time one day before the final trial. This trial's exclusion could somewhat increase the power and decrease the p-value, but the high variability among the other participants renders its impact insignificant.

5.5 Future research

This experiment was conducted in a public gym inside the Norwegian School of Sport Sciences, where the 1080 Quantum system was mounted. Because of this, the experiments were not possible to conduct in a room by ourselves. Future research should compare maximal or muscular endurance tests in an environment where the participants are completely alone. The social facilitation effect could be twice as evident when the researchers reportedly are absent from the room when the test is conducted (Bond & Titus, 1983, p. 271; van Meurs et al., 2022, p. 22).

The familiarization session for future research should be longer to ensure that the task is more familiar prior to testing and to make sure to eliminate the practice-based improvements. This would also arguably make the social facilitation effect more evident because of familiarity with the task conducted. The resting periods between trials could also be extended to at least seven days apart to reduce practice-based improvements and to maintain sufficient rest between each test if conducted in an isokinetic dynamometer.

It would be beneficial for future research to examine the impact of different training regimes (such as powerlifting, bodybuilding, and endurance training) on an individual's self-efficacy and social facilitation effects when they have a spotter present. It may be necessary to compare participants who engage in high intensity/maximal strength training with those who mainly perform resistance exercises at lower intensities when conducting maximal strength tests. The participants in this study were highly experienced in resistance training. As such, the findings may not be applicable to other groups. Future research should investigate the effects of spotters on individuals with varying levels of experience. Specifically, it would be interesting to determine whether those who are less experienced with strength tasks benefit less from spotters. This could be particularly relevant for individuals who rely on personal trainers for guidance. Additionally, experiments should examine whether familiar peers or unfamiliar peers have differing effects on strength tasks, as well as the extent to which the number of spotters impacts performance.

5.6 Practical applications

Even though the study had a small sample size, it indicated that having a spotter during workouts can result in better upper and lower body strength, both in terms of endurance and maximal performance. Based on effect sizes conducted during this experiment, one could argue that effects of having a spotter is beneficial regardless of verbal encouragement or not. Coaches and exercise professionals should prioritize clients' safety by ensuring they work out in proximity to others and use spotters. Spotting not only provides safety but also fosters effort and performance during working sets. Providing verbal support during sets and offering specific feedback between sets can maximize the role of the spotter and improve the chances of success for the client or athlete in achieving their desired weight or number of repetitions.

This recent study demonstrated that verbal encouragement is crucial during field-based testing and research. The results revealed significant improvements in individuals who received supportive spotting during testing. To maintain consistency and avoid any influence on individual variation or potential performance improvements in some participants, it is crucial to standardize the behavior and approach of the spotter/researcher during testing.

These findings, in addition to previous research, suggest that working out in a crowded gym may have its benefits. Although some individuals may feel hesitant to join during peak hours due to the high volume of people, it can lead to improvements by enhancing self-presentation/self-awareness and self-efficacy. While some people may experience anxiety and performance inhibition, this study found no significant differences in trait or state anxiety levels. However, it was observed that the female participants in the study displayed inclinations towards higher trait anxiety levels and lower performance improvements compared to the males. There is a possibility that the level of trait anxiety may have an impact on performance in strength tasks when there is an audience present.

6.0 Conclusion

To summarize, the study found that having a supportive spotter led to the best results for both squats and bench press, with the highest peak and mean force during various repetition ranges. While the passive spotter condition showed higher mean scores compared to the alone condition throughout the study, no significant conclusion could be drawn. No differences in state or trait anxiety were observed between genders or conditions. The spotter conditions had the greatest impact on performance during squats and showed greater improvement among male participants. The information gained from this study suggests that researchers, strength coaches, and personal trainers should recognize the importance of verbal encouragement and the presence of a spotter during testing to optimize performance or the necessity for standardization to ensure consistency.

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Appendix 1: Mind Garden Permission

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State-Trait Anxiety Inventory for Adults Instrument (Adult Form) and Scoring Guide

English and Norwegian versions

Developed by Charles D. Spielberger
in collaboration with R.L. Gorsuch, R. Lushene, P.R. Vagg, and G.A. Jacobs

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Appendix 2: STAI-T

STAI-T [© Spielberger, 1983]

INSTRUKSJON: Nedenfor finner du en rekke setninger som ofte brukes for å beskrive hvordan en føler seg I ALMINNELIGHET. Les hver setning og sett ring rundt det tallet til høyre som passer best med HVORDAN DU VANLIGVIS HAR DET. Det finnes ingen riktige eller gale svar. Ikke tenk for lenge på hver setning, men svar slik som du umiddelbart synes passer best med HVORDAN DU HAR DET TIL VANLIG.

	Aldeles ikke	Litt	Nokså mye	Svært mye
21. Jeg føler meg vel.	1	2	3	4
22. Jeg føler meg nervøs og rastløs.	1	2	3	4
23. Jeg er tilfreds med meg selv.	1	2	3	4
24. Jeg skulle ønske jeg var like lykkelig som alle andre synes å være.	1	2	3	4
25. Jeg føler meg mislykket.	1	2	3	4
26. Jeg føler meg uthvilt.	1	2	3	4
27. Jeg er rolig og avbalansert.	1	2	3	4
28. Jeg føler at vanskelighetene hoper seg opp, slik at jeg ikke kan løse dem.	1	2	3	4
29. Jeg engster meg for mye over småting.	1	2	3	4
30. Jeg er lykkelig.	1	2	3	4
31. Jeg har urovekkende tanker.	1	2	3	4
32. Jeg mangler selvtillit.	1	2	3	4
33. Jeg føler meg trygg.	1	2	3	4
34. Jeg tar avgjørelser lett.	1	2	3	4
35. Jeg føler meg utilstrekkelig.	1	2	3	4
36. Jeg er fornøyd og tilfreds.	1	2	3	4
37. Jeg er plaget av uviktige tanker.	1	2	3	4
38. Jeg tar skuffelser så hardt at jeg ikke kan kvitte meg med dem.	1	2	3	4
39.Jeg er en stø og stabil person.	1	2	3	4
40. Jeg blir nervøs og ute av meg når jeg tenker på mine aktuelle problemer.	1	2	3	4

Appendix 3: STAI-S

STAI-S [© Spielberger, 1983]

INSTRUKSJON: Nedenfor finner du en rekke setninger som ofte brukes for å beskrive hvordan en føler seg I ØYEBLIKKET. Les hver setning og sett ring rundt det tallet til høyre som passer best med HVORDAN DU HAR DET NÅ. Det finnes ingen riktige eller gale svar. Ikke tenk for lenge på hver setning, men svar slik som du umiddelbart synes passer best for deg AKKURAT NÅ.

	Aldeles ikke	Litt	Nokså mye	Svært mye
1. Jeg føler meg rolig.	1	2	3	4
2. Jeg føler meg trygg.	1	2	3	4
3. Jeg er anspent.	1	2	3	4
4. Jeg føler meg presset.	1	2	3	4
5. Jeg føler meg vel.	1	2	3	4
6. Jeg føler meg oppskaket.	1	2	3	4
7. Akkurat nå tar jeg sorgene på forskudd.	1	2	3	4
8. Jeg føler meg tilfreds.	1	2	3	4
9. Jeg føler meg skremt.	1	2	3	4
10. Jeg har det behagelig.	1	2	3	4
11. Jeg er sikker på meg selv.	1	2	3	4
12. Jeg føler meg nervøs.	1	2	3	4
13. Jeg er skjelven.	1	2	3	4
14. Jeg føler meg ubestemt.	1	2	3	4
15. Jeg er avslappet.	1	2	3	4
16. Jeg er fornøyd.	1	2	3	4
17. Jeg er bekymret.	1	2	3	4
18. Jeg føler meg forvirret.	1	2	3	4
19.Jeg føler meg stabil.	1	2	3	4
20. Jeg har det bra.	1	2	3	4

Appendix 4: SurveyXact Questionnaire

Hva er ditt Forsøksperson NR?

Oppgi ditt kjønn

- Mann
- Kvinne

Når er du født? Oppgi din fødselsdato

dd.mm.åååå

Hva er din høyde? Oppgi din høyde i cm (oppgi med .5 om dette er tilfellet)

Hva er din kroppsvekt? Oppgi din kroppsvekt i kg (oppgi med .5 om dette er tilfellet)

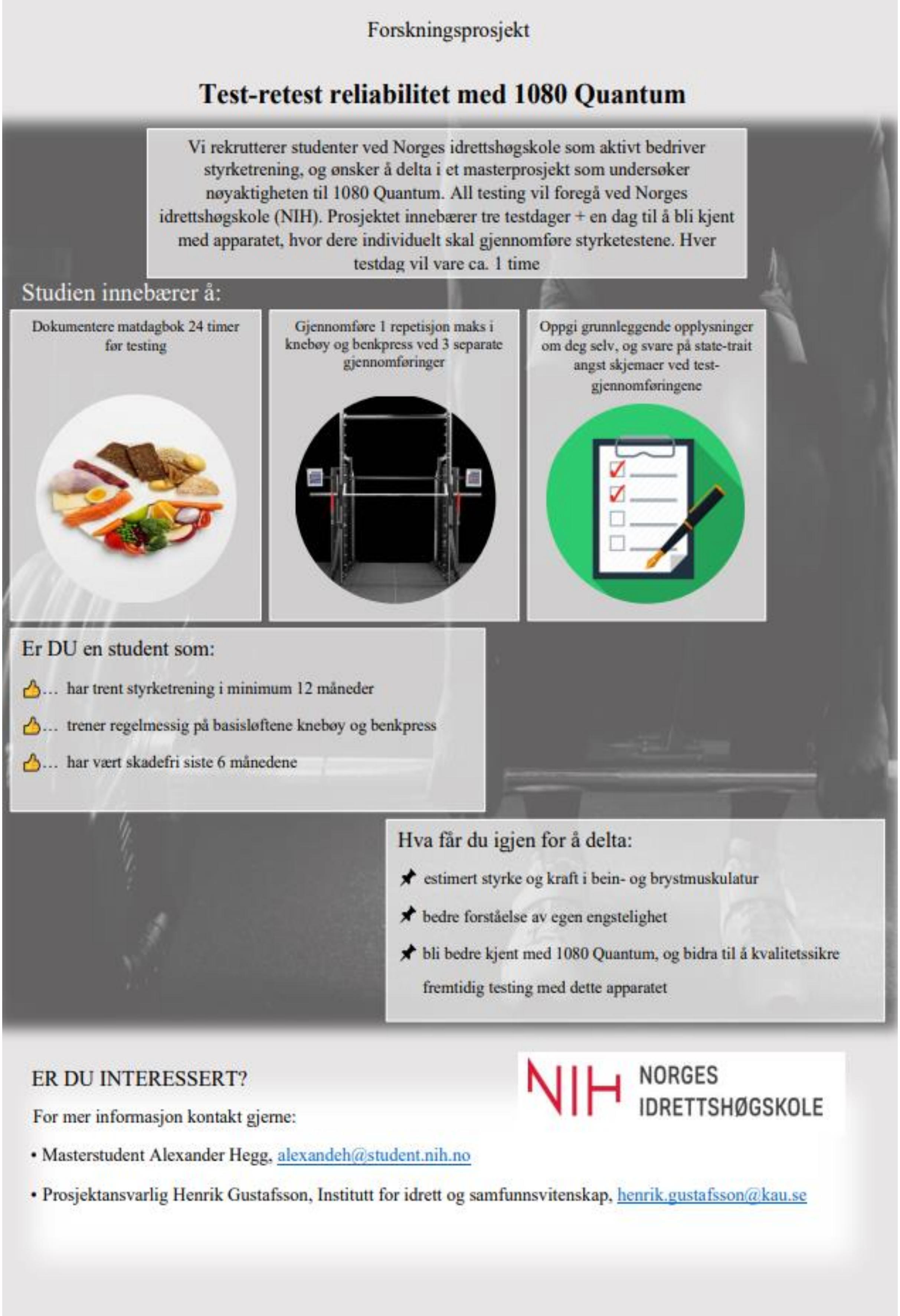
Hvor lenge har du trent styrke? Oppgi ditt erfaringsnivå med styrketrening i antall år røft estimert (oppgi med .5 om dette er tilfellet)

Deltar du i organisert idrett eller har en hobby som innebærer annen fysisk aktivitet? Oppgi hvilken organisert idrett du bedriver. Dersom du ikke bedriver noen, oppgi mosjonist.

Hvor ofte trener du styrke ukentlig? Dersom du bedriver en organisert idrett eller annen hobby, oppgi hvor ofte du trener dette også. Oppgi antall styrketreningsøkter og idrett/hobby separat.

PREVIOUS FINISH

Appendix 5: Recruitment poster



Appendix 6: Information letter

Vil du delta i forskningsprosjektet
«1RM Test-retest med 1080 Quantum»?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å teste reliabiliteten til et motorisk drevet apparat, ved å gjennomføre 1RM i knebøy og benkpress ved 3 ulike testdager. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

Med dagens teknologi har det i flere anledninger blitt utviklet apparater montert med elektroniske motorer som skal kunne brukes til testing og som en del av treningen. 1080 Quantum her på Norges idrettshøgskole er en slik maskin, og er relativt ny i forskningssammenheng. Når man skal benytte et måleinstrument for å måle muskelstyrke blant deltagerne, er det derfor viktig at man kan stole på de tallene som genereres og den gjennomføringsprotokollen som benyttes. I denne studien ønsker jeg derfor ved bruk av flere styrketest-gjennomføringer, måle apparatets test-retest reliabilitet samt protokollen som er blitt tilpasset for 1080 Quantum apparatet.

For å være forsøksperson i dette masterprosjektet må du være frisk, og du må ha minst 12 måneders erfaring med styrketrening.

Hvem er ansvarlig for forskningsprosjektet?

Institutt for idrett og samfunnsvitenskap ved Norges idrettshøgskole er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?

Jeg vil benytte meg av studenter her på Norges idrettshøgskole, som er friske og har minimum 12 måneders erfaring med styrketrening. Det er også ønskelig at dere kjenner til øvelsen knebøy og benkpress relativt godt. Det er ønsket å benytte rundt 20 personer, som er likt fordelt av begge kjønn.

Hva innebærer det for deg å delta?

Hvis du velger å delta i prosjektet, vil du få utdelt en lenke hvor du skal fylle ut et elektronisk spørreskjema. Dette skjemaet vil innebære generelle personopplysninger (kjønn, høyde, vekt og alder) samt erfaringsnivå med styrketrening, deltagelse i idretter og en trait-angst skala, som skal ta for seg individuelle forskjeller i deltagergruppen. Dette vil ta deg maks 10 minutter. Dine svar fra spørreskjemaet blir registrert elektronisk.

All testing vil foregå ved Norges idrettshøgskole (NIH). Prosjektet innebærer tre testdager + en dag til å bli kjent med apparatet, hvor dere individuelt skal gjennomføre styrketestene. Testene vil bli gjennomført med en test under vanlig omstendigheter uten tilsnakk, en gjennomføring bak skillevegger og med ørepropper for å fjerne mulige distraksjoner, samt en gjennomføring hvor man skal bli oppmuntret gjennom tilsnakk underveis i gjennomføring. Selve testingen vil foregå ved konsentrisk hastighet på 0,6 og 0.3 m/s i knebøy og 0,4 og 0.2 m/s i benkpress. For hver hastighet gjennomføres 2 seirer med 1-2 maksimale løft avhengig av hastigheten. I den 5 serien vil det gjøres 10 repetisjoner med maksimal innsats (0.3 og 0.2 m/s i henholdsvis knebøy og benkpress). Det vil gis 3-4 min pause mellom hver serie. Hver testdag vil vare rundt 1 time (oppvarming, flere forsøk på makstest for både benk og knebøy, samt pauser). Etter hver av gjennomføringene skal det også besvares et skriftlig spørreskjema, som skal måle deres grad av angst ved gjennomføring for å ta høyde for mulige faktorer som kan påvirke selve gjennomføringen.

Det er frivillig å delta

Det er helt 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.

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.
Alle personopplysninger vil bli avidentifisert. Dette betyr at resultater og opplysninger ikke blir lagret under navn, men en tallkode. Navnet ditt blir koblet til en tallkode og vil bli oppbevart i en safe ved Institutt for idrett og samfunnsvitenskap ved Norges idrettshøgskole.

Det er kun prosjektansvarlige student, veileder og ledelsen ved instituttet som har tilgang til denne.

Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?

Prosjektet vil etter planen avsluttes 31.07.2023. Etter prosjektslutt skal kodelisten slettes og dermed vil all data være anonymisert. Dine personopplysninger vil ikke kunne identifiseres i publikasjoner.
Etter 31.07.2023 vil derfor all data i prosjektet slettes.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke. På oppdrag fra Norges idrettshøgskole har NSD (Norsk senter for forskningsdata AS) 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:

- Norges Idrettshøgskole ved masterstudent Alexander Hegg (alexandeh@student.nih.no) eller veileder/prosjektleder Henrik Gustafsson (henrik.gustafsson@kau.se, tlf: 70 6967260), biveileder Frank Eirik Abrahamsen (frankea@nih.no, tlf: 23262431) og biveileder Gøran Paulsen (goran.paulsen@nih.no, tlf: 93429420).
- Vårt personvernombud: Rolf Haavik (personvernombud@nih.no, tlf: 90733760)

Hvis du har spørsmål knyttet til Personverntjenester sin vurdering av prosjektet, kan du ta kontakt med:

- Personverntjenester på epost (personverntjenester@sikt.no) eller på telefon: 53 21 15 00.

Med vennlig hilsen
Alexander Hegg, masterstudent ved Norges idrettshøgskole,
Henrik Gustafsson, PhD, professor ved Norges idrettshøgskole, Gøran Paulsen, PhD, førsteamanuensis ved Norges idrettshøgskole og Frank Abrahamsen, PhD, førsteamanuensis ved Norges idrettshøgskole

---

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *«1RM test-retest med 1080 Quantum»*, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i studien
- ☐ å delta i spørreskjemaene
- ☐ at mine opplysninger behandles frem til prosjektet er avsluttet (31.07.2023)

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

---

(Signert av prosjektdeltaker, dato)

Appendix 7: NSD permission

Sikt

[Meldeskjema](#) / [Sosial fasilitering med tilstedeværelse av andre og prestasjon i styrket...](#) / Vurdering

Vurdering av behandling av personopplysninger

Referansenummer	**Vurderingstype**	**Dato**
482377	Standard	14.11.2022

Prosjekttittel
Sosial fasilitering med tilstedeværelse av andre og prestasjon i styrketrening

Behandlingsansvarlig institusjon
Norges idrettshøgskole / Institutt for idrett og samfunnsvitenskap

Prosjektansvarlig
Frank Eirik Abrahamsen

Student
Alexander Hegg

Prosjektperiode
01.11.2022 - 31.07.2023

Kategorier personopplysninger
Alminnelige
Særlige

Lovlig grunnlag
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)
Uttrykkelig samtykke (Personvernforordningen art. 9 nr. 2 bokstav a)

Behandlingen av personopplysningene er lovlig så fremt den gjennomføres som oppgitt i meldeskjemaet. Det lovlige grunnlaget gjelder til 31.07.2023.

Meldeskjema

Kommentar
OM VURDERINGEN
Personverntjenester har en avtale med institusjonen du forsker eller studerer ved. Denne avtalen innebærer at vi skal gi deg råd slik at behandlingen av personopplysninger i prosjektet ditt er lovlig etter personvernregelverket.

Personverntjenester har nå vurdert den planlagte behandlingen av personopplysninger. Vår vurdering er at behandlingen er lovlig, hvis den gjennomføres slik den er beskrevet i meldeskjemaet med dialog og vedlegg.

VIKTIG INFORMASJON TIL DEG
Du må lagre, sende og sikre dataene i tråd med retningslinjene til din institusjon. Dette betyr at du må bruke leverandører for spørreskjema, skylagring, videosamtale o.l. som institusjonen din har avtale med. Vi gir generelle råd rundt dette, men det er institusjonens egne retningslinjer for informasjonssikkerhet som gjelder.

DEL PROSJEKTET MED PROSJEKTANSVARLIG
Det er obligatorisk for studenter å dele meldeskjemaet med prosjektansvarlig (veileder). Det gjøres ved å trykke på "Del prosjekt" i meldeskjemaet. Om prosjektansvarlig ikke svarer på invitasjonen innen en uke må han/hun inviteres på nytt

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige personopplysninger og særlige kategorier av personopplysninger om helse frem til 31.07.2023.

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

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

Behandlingen av særlige kategorier av personopplysninger er basert på uttrykkelig samtykke fra den registrerte, jf. personvernforordningen art. 6 nr. 1 a og art. 9 nr. 2 a.

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

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

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

Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18) og dataportabilitet (art. 20).

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
Personverntjenester legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

For å forsikre dere om at kravene oppfylles, må prosjektansvarlig følge interne retningslinjer/rådføre dere med behandlingsansvarlig institusjon.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til oss ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilken type endringer det er nødvendig å melde:
https://www.nsd.no/personverntjenester/fylle-ut-meldeskjema-for-personopplysninger/melde-endringer-i-meldeskjema

Du må vente på svar fra oss før endringen gjennomføres.

OPPFØLGING AV PROSJEKTET
Vi vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Kontaktperson hos oss: Janniche Linde

Lykke til med prosjektet!

Appendix 8: NIH's ethic permission

Henrik Gustafsson
Institutt for idrett og samfunnsvitenskap

OSLO 14. november 202

Søknad 255 – Sosial fasilitering med tilstedeværelse av andre og prestasjon i styrketrening

Vi viser til søknad, prosjektbeskrivelse, informasjonsskriv, intervjuguide og innsendt melding til NSD.

I henhold til retningslinjer for behandling av søknad til etisk komite for idrettsvitenskapelig forskning på mennesker, har komiteen i møte 10. november 2022 konkludert med følgende.

Vurdering
I søknaden står det at deltakerne i prosjektet blant annet må trene regelmessig på basisløftene knebøy og benkpress. Komiteen ber om at dette inklusjonskriteriet tas med i informasjonsskrivet. Komiteen minner for øvrig om viktigheten av å screene deltakere for skader eller sykdom som ikke er forenlig med deltakelse.

Vedtak
På bakgrunn av forelagte dokumentasjon finner komiteen at prosjektet er forsvarlig og at det kan gjennomføres innenfor rammene av anerkjente etiske forskningsetiske normer nedfelt i NIHs retningslinjer. Til vedtaket har komiteen lagt følgende forutsetning til grunn:

- *Vilkår fra NSD følges*
- *At samtykke oppdateres iht ovennevnte merknad*
- *At det etableres hensiktsmessig screening av deltakere før de inkluderes i prosjektet*

Komiteen gjør oppmerksom på at vedtaket er avgrenset i tråd med fremlagte dokumentasjon. Dersom det gjøres vesentlige endringer i prosjektet som kan ha betydning for deltakernes helse og sikkerhet, skal dette legges fram for komiteen før eventuelle endringer kan iverksettes.

Med vennlig hilsen

Anne Marte Pensgaard

Professor Anne Marte Pensgaard

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