Bachelor's thesis

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Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

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The Effect of Physical Exercise in the Treatment of Insomnia

Bachelor's thesis in BEV2900
Supervisor: Paul Jarle Mork
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Abstract:

Purpose: Insomnia is one of the most common health problems in our society. Approximately 30% of adults has one or more symptoms of insomnia and approximately 10% meet the diagnostic criteria for insomnia. Due to most research regarding insomnia primarily uses psychological treatment methods, this literature review will investigate if physical exercise has an effect on insomnia symptoms and what form of exercise yields the greatest effect. **Methods:** The literature search was carried out using PubMed and Google Scholar. Participants were at least 18 years old and diagnosed with insomnia. All studies included were randomized controlled trials. Insomnia symptoms were primarily assessed using the questionnaires: Pittsburgh Sleep Quality Index, Insomnia Severity Index and Basic Nordic Sleep Questionnaire. **Results:** 8 RCTs were included. 7 found that exercise improved symptoms of insomnia in the intervention groups compared to the control groups, regardless of exercise form. **Conclusion:** Based on results all the different forms of exercise led to improvements in insomnia symptoms. However, it's difficult to draw any clear conclusions on which form of exercise yields the greatest effect in insomnia symptoms. There is need for more research upon this subject, but it seems that exercise in general shows improvements in insomnia symptoms.

Abstrakt:

Bakgrunn: Insomni (søvnløshet) er en av de vanligste helserelaterte problemene i samfunnet. Omtrent 30% av voksne mennesker har en eller flere symptomer på insomni og omtrent 10% møter kriteriet for å diagnostiseres med insomni. Siden mesteparten av forskning relatert til insomni hovedsakelig bruker psykologiske behandlingsmetoder, vil denne litteraturstudien undersøke om fysisk trening har en effekt på insomni symptomer og hvilken type trening som gir størst effekt. **Metode:** Litteratursøket ble gjennomført ved bruk av PubMed og Google Scholar. Deltakere var minst 18 år gamle og diagnostisert med insomni. Kun randomiserte kontrollstudier er inkludert. Symptomer på insomni ble vurdert med spørreskjemaene: Pittsburgh Sleep Quality Index, Insomnia Severity Index og Basic Nordic Sleep Questionnaire. **Resultat:** 8 studier ble inkludert i litteraturstudien. 7 studier fant at trening forbedret symptomer på insomni i intervensjonsgruppene sammenlignet med kontrollgruppene, uansett treningstype. **Konklusjon:** Resultatene viser at alle de forskjellige treningstypene førte til forbedringer i insomni symptomer. Det er likevel vanskelig å trekke noen klar slutning om hvilken type trening som ga størst effekt på insomni symptomer. Det er behov for mer forskning på dette temaet, men det virker som at trening generelt viser forbedringer i insomni symptomer.

Keywords: Exercise • Insomnia • Physical activity

1. Introduction

Insomnia is one of the most common health problems in our society and is defined as a patient-reported condition, characterized by four symptoms on different aspects of sleep (1). The four symptoms are: 1) falling asleep or having a problem with staying asleep; 2) nighttime awakenings; 3) waking up too early in the morning with inability to resume sleep; and 4) daytime sleepiness (1). Data from the Norwegian Directorate of Health (2) shows that one in three adults have weekly reports of sleep-related troubles, while up to 15% of the Norwegian population have insomnia of a more long-lasting nature. This isn't just a problem in Norway. A systematic review by Roth (3), based on population-based studies sampled from different countries over the world, states that approximately 30% of adults has one or more symptoms of insomnia. The same report concludes that approximately 10% of adults meet the diagnostic requirement for insomnia.

Methods of assessing sleep quality and other aspects of sleep can be measured in both subjective and objective ways. Subjective assessments of sleep are primarily assessed by using validated questionnaires, while objective assessments are usually carried out by different types of sensors, such as wrist actigraphy and polysomnography. Sleep studies often contain both assessment methods. However, Seol et al. (4) reported minimal correlation between the two methods of assessment, as they seem to reflect different aspects of sleep quality. One of the most used questionnaires in clinical literature for assessing sleep quality and sleep disturbances, is The Pittsburgh Sleep Quality Index (PSQI)(5). In this questionnaire a subject evaluates their monthly average sleep quality by answering nineteen individual questions, touching upon seven different aspects of sleep. The answers of these nineteen questions will provide a total score. Based on the total score, the subject can be categorized into "poor sleepers", "good sleepers" or into more severe categories. The psychometric properties of The Pittsburgh Sleep Quality Index have been clinically assessed in an 18-month study and found high specificity and sensitivity in distinguishing "good sleepers" and "poor sleepers".

While the PSQI is used to assess sleep quality, the Insomnia Severity Index (ISI) is used to detect insomnia within a group of patients with insomnia symptoms (6). The questions asked are somewhat familiar to the PSQI but are more subjective, in a way that they ask more about how you feel. The ISI may for example ask how you feel about your sleep duration, while the PSQI only wants to know the exact duration of your sleep. The ISI was designed to assess the severity of both daytime and nighttime components of insomnia, because insomnia affects an individual's physical and psychological well-being both day and night. Although the main questionnaires used in this review paper are the ISI and PSQI, Tan et al. (7) exclusively used the Basic Nordic Sleep Questionnaire (BNSQ) to detect difficulty falling asleep, maintaining sleep and early morning awakenings. The BNSQ has proven to be a valid tool in a variety of studies performed in Nordic countries (8). The basic scale is: 1) never or less than once per month; 2) less than once per week; 3) on 1-2 nights per week; 4) on 3-5 nights per week; and 5) every night or almost every night.

Engaging in daily physical exercise has been associated with improvements in sleep quality in clinical literature, (4). Different forms of exercise with different levels of intensity seem to have varying effects on sleep quality. The different forms of exercise highlighted in this review paper are aerobic exercise, resistance training, stretching, mobility and movement exercises, and Tai Chi. Huston and McFarlane (9) defines Tai Chi as a meditative martial art consisting of a series of gentle movements that strengthen and relax the body and mind. While the most common form of exercise consists of either aerobic exercise or resistance training, there are physical exercise methods, like zero-time exercise (ZTEx), that simplifies and lowers the threshold for doing exercise. ZTEx is a modern small-step approach to integrating simple strength- and stamina-enhancing physical activity into daily life, with no need for equipment, money or extra time (10). In this review, ZTEx will go under the terms of stretching, mobility and movement exercises, based on the small-step approach and short intervention time.

The association between improvements in sleep quality and physical exercise in the general population has been established and found to have a moderately positive effect (11). If there is a difference in effect on insomnia symptoms between forms of exercise, this would be a of great interest for the facilitation of exercise in rehabilitation programs. In this review paper we will investigate if physical exercise has an effect on insomnia symptoms, and what form of physical exercise yields the greatest effect.

2. Methods

The literature search was carried out using the databases PubMed and Google Scholar. Keywords used were: “exercise”, “physical activity” and “insomnia”. Keywords were combined using AND and/or OR in different combinations to find as many relevant papers as possible. The search provided an initial result of 106 original papers that were of interest. Furthermore, a manual search was carried out in the reference list of relevant papers, to identify additional papers that wasn’t already identified in the literature search. The reference list of the 6 included papers provided 2 additional papers that are relevant for this review. In total, the search resulted in 8 relevant studies that were used in this review paper.

2.1. Inclusion and exclusion criteria

All papers that were included had to be published in English, conducted on humans, and keywords had to be present in abstract, title or keywords. The study design of the relevant papers had to be a randomized controlled trail (RCT) to lower the risk of bias. Additionally, all the relevant papers had to be published from 2010 to the present, and participants had to be at least 18 years of age. Based on the title and abstract, 58 papers were excluded. Exclusion criteria were 1) when physical exercise was not admitted to the participants, 2) when the participants wasn’t diagnosed with insomnia, and 3) when the studies included pregnant women.

3. Results

8 papers (7,12–18) included a total of 866 participants which were either divided into one or more intervention groups or a control group (table 1). Main results are presented using either total PSQI- or ISI-score, or both in the studies that used both outcome measures. Tan et al. (7) and Passos et al. (14) presented their results using sub scores within the questionnaire, rather than total scores for PSQI or ISI. Tan et al. (7) was the only one to present partial results by using the BNSQ. Exercise included both aerobic exercise and resistance training with different levels of intensity, as well as other forms of exercise like Tai Chi and stretching, mobility and movement exercises and zero-time exercise.

Table 1: Main results including outcome measures.

Author (s)	Intervention (participants)	Outcome measures	Main results
Suna et al. (2014)	**Intervention group (*n=54*):** 12 weeks. Two 1-hour sessions a week consisting of both aerobic exercise and resistance training. Intensity: 9-13 on Borg scale. **Control group (*n=52*):** 12 weeks. No exercise, education on health benefits following exercise.	PSQI	Mean difference of 1.1 points* in PSQI in favor of the intervention group compared to the control group at 12 weeks.
Hartescu et al. (2015)	**Intervention group (*n=17*):** 6 months, ≥150 minutes of MVPA containing both aerobic exercise and resistance training. **Control group (*n=18*):** Continue their prerecruitment lifestyle in the 6-month period.	ISI	Mean difference of 3.2 points* in ISI in favor of the intervention group compared to the control group at 6 months.
Siu et al. (2021)	**Intervention group 1 (*n=91*):** 12 weeks. Three 1-hour sessions per week. Tai Chi in supervised groups. **Intervention group 2 (*n=87*):** 12 weeks. Three 1-hour sessions per week. Brisk walking, and resistance training in supervised groups.	ISI PSQI	Mean difference in ISI and PSQI points in favor of intervention group 1 compared to the control group at 12 weeks (T1) and 24 months (T2): T1: 4.1 points** → T2: 2.7 points** T1: 2.9 points** → T2: 1.7 points**

	Control group (*n=90*): 12 weeks. No intervention.		Mean difference in ISI and PSQI points in favor of intervention group 2 compared to the control group at 12 weeks (T1) and 24 months (T2):
		ISI	T1: 1.2 points* → T2: 0.9 points*
		PSQI	T1: 2.0 points** → T2: 1.9 points**
			Mean difference in ISI and PSQI points in favor of intervention group 1 compared to intervention group 2 at 12 weeks (T1) and 24 months (T2):
		ISI	T1: 2.1 points** → T2: 0.8 points
		PSQI	T1: 1.7 points** → T2: 0.6 points
Tan et al. (2016)	**Intervention group (*n=24*):** 6 months, prescribed: 30-60 minutes, one to five sessions per week of aerobic exercise at 60%-75% of estimated MaxHR. +One supervised exercise session per week **Control group (*n=21*):** Continue their prerecruitment lifestyle in the 6-month period.	*Sleep monitoring system:* Sleep onset latency (min) Wake after sleep onset (min) Sleep efficiency (%) *BNSQ:* Frequency of difficulty initiating sleep	 Mean difference of <u>12.8 minutes*</u> in sleep onset latency in favor of the intervention group compared to the control group at 6 months. No significant difference in wake after sleep onset between the groups. No significant difference in sleep efficiency between the groups. Mean difference of <u>0.5 points*</u> in difficulty initiating sleep in favor of the intervention group compared to the control group at 6 months.
Passos et al. (2010)	**Intervention group 1 (*n=12*):** Moderate-intensity aerobic exercise (MAE). 2 sleepovers in sleep laboratory. **Intervention group 2 (*n=12*):** High-intensity aerobic exercise (HAE). 2 sleepovers in sleep laboratory. **Intervention group 3 (*n=12*):** Moderate-intensity resistance exercise (MRE). 2 sleepovers in sleep laboratory. **Control group (*n=12*):** 2 sleepovers in sleep laboratory.	*Polysomnography and sleep log.*	No significant differences were found in any of the intervention groups compared to the control group.

Wiklund et al. (2018)	**Intervention group 1 (*n=100*):** 8 weeks. Two 1-hour sessions per week, two days in-between sessions and at the same time points of the day. Both aerobic exercise and resistance training. **Intervention group 2 (*n=99*):** 8 weeks. Stress management. **Control group (*n=100*):** 7 weeks. One 2-hour session a week. Sharing experiences with insomnia.	ISI ISI	Mean difference in ISI points in favor of intervention group 1 compared to the control group at 8 weeks (T1), 6 months (T2) and 12 months (T3): T1: 1.7 points* T2: 0.6 points** T3: 2.1 points** Mean difference in ISI points in favor of intervention group 2 compared to the control group at 8 weeks (T1), 6 months (T2) and 12 months (T3): T1: 1.4 points T2: 0.2 points T3: 1.8 points**
D'Aurea et al. (2019)	**Intervention group 1 (*n=10*):** 4 months. Supervised resistance training sessions (50 min), 3 times a week. 50-60% of 1RM. **Intervention group 2 (*n=10*):** 4 months. Performed a specified stretching protocol (50 min), 3 times a week. **Control group (*n=8*):** 4 months. No intervention.	ISI PSQI *Wrist actigraphy:* Total sleep time (min) Sleep onset latency (min) Sleep efficiency (%)	Mean difference of 12.8 points* in ISI in favor of intervention group 1 compared to the control group at 4 months. Mean difference of 10.4 points* in ISI in favor of intervention group 2 compared to the control group at 4 months. Mean difference of 5.2 points* in PSQI in favor of intervention group 1 compared to the control group at 4 months. Mean difference of 3.8 points* in PSQI in favor of intervention group 2 compared to the control group at 4 months. No significant difference in total sleep time in either intervention groups compared the control group at 4 months. Mean difference of 9.3 minutes* (intervention group 1) and 7.4 minutes* (intervention group 2) in sleep onset latency compared to the control group at 4 months. Mean difference of 6.7%* (intervention group 1) and 7.3%* (intervention group 2) in sleep efficiency compared to the control group at 4 months.

		Wake after sleep onset (min)	Mean difference of 12.9 minutes* (intervention group 1) and 10.7 minutes* (intervention group 2) in wake after sleep onset compared to the control group at 4 months.
Yeung et al. (2018)	**Intervention group (*n=18*):** Two 2-hour sessions of ZTEx one week apart, then logging for 8 weeks. **Control group (n=19):** Two 2-hour sessions of sleep hygiene education.	ISI	Mean difference of 4.0 points* in ISI in favor of the intervention group compared to the control group at 8 weeks.

MVPA = Moderate- to vigorous-intensity physical activity, MaxHR = Maximal Heart Rate, 1RM = One repetition maximum.

Statistical significance: *p<0.05, **p<0.01

Wiklund et al. (18) found a significant decrease in ISI points for the exercising intervention group compared to controls at all time points post intervention, and the difference was significantly larger at six months and twelve months. In the intervention group that performed stress management, the decrease over time was significant after twelve months of follow-up, but not for the other time points. Yeung et al. (12) found a significant decrease in ISI points for the intervention group compared to controls, when intervention contained zero-time exercise. D'Aurea et al. (13) reported significant improvements in sleep onset latency, sleep efficiency and wake after sleep onset for both intervention groups compared to controls. They also found a significant decrease in both ISI and PSQI for both intervention groups, where resistance training yielded the largest decrease for both ISI and PSQI. Siu et al. (15) found a significant decrease in both ISI and PSQI points for both low intensity resistance training and Tai Chi compared to controls, at all time points post intervention. There was also reported a significantly large decrease in both ISI and PSQI points for Thai Chi compared to low intensity resistance training after twelve weeks of intervention, but not after twenty-four months of follow-up.

Suna et al. (16) found a significant decrease in PSQI points for the intervention group compared to controls, when intervention contained a combination of aerobic exercise and resistance training at low intensity. Tan et al. (7) reported that aerobic exercise at low-moderate intensity among overweight and obese men significantly reduced sleep onset latency and a lowered frequency of difficulty initiating sleep. Hartescu et al. (17) found a significant decrease in ISI points for the intervention group compared to controls, when intervention contained a combination of moderate-vigorous aerobic exercise and resistance training. Passos et al. (14) found significant differences in sleep onset latency, sleep efficiency, total sleep time and total wake time within intervention group 1, but reported no significant differences in any of the intervention groups compared to controls.

4. Discussion

All the studies covered in this review that used ISI and/or PSQI (12,13,15–18), reported a significant decrease in ISI and/or PSQI points for the exercising intervention groups compared to controls, regardless of training intensity and type of exercise. Tan et al. (7) found a significant decrease in frequency of difficulty initiating sleep by using the BNSQ. Tan et al. (7), Passos et al. (14) and D'Aurea et al. (13) included parameters of recorded data from wrist actigraphy and polysomnography. The parameters included in this review paper were sleep onset latency, sleep efficiency, total sleep time and wake time after sleep onset. D'Aurea et al. (13) and Tan et al. (7) both found a significant difference in sleep onset latency in the intervention groups compared to the control groups. Tan et al. (7) did not find a significant difference in favor of the aerobic exercise intervention group compared to the control group on sleep efficiency and wake time after sleep onset, but found a significant difference within the intervention group. However, D'Aurea et al. (13) found a significant difference in both intervention groups compared to controls in all parameters, except for total sleep time. In contrast, Passos et al. (14) found no significant difference for the intervention groups compared to the control group in sleep onset latency, sleep efficiency and wake time after sleep onset in their study of acute effects on sleep, by different types of exercise. They did however find a significant difference within the moderate-intensity aerobic exercise group on these parameters.

Tan et al. (7), which is a similar study to Passos et al. (14), found a significant difference between groups on the included parameters. The study used a personalized exercise intervention which was conducted by two experienced exercise trainers. This may tell us that a personalized exercise intervention with some supervision may be more beneficial than an individual form of intervention. In contrast, Passos et al. (14) intervention lasted only two days, while Tan et al. (7) had 6 months of intervention. In the shorter study there was no significant difference between the groups, while the longer study found a significant difference. D'Aurea et al. (13), which also found a significant difference in the three parameters, was also conducted over a longer time of four months. This may indicate that the effects that physical exercise has on sleep and insomnia improves over time. Both D'Aurea et al. (13) and Tan et al. (7) backs up the results found within the intervention group preforming moderate-intensity aerobic exercise in Passos et al. (14), that there could be some effect of spontaneous physical exercise on sleep.

4.1 Form of exercise and intensity

All the studies using resistance training in their study (13–18), except for Passos et al. (14), concluded that resistance training at different levels of intensity had a significant effect on insomnia symptoms. D'Aurea et al. (13) and Passos et al. (14) was the only ones to have pure resistance training sessions in one intervention group. All the studies using aerobic exercise in their study (7,14–18), except for Passos et al. (14), concluded that aerobic exercise at different levels of intensity had a significant effect on insomnia symptoms. Passos et al. (14) had pure aerobic exercise sessions in one intervention group, while Tan et al. (7) was the only one that exclusively performed aerobic exercise for their entire study. D'Aurea et al. (13) had pure stretching, mobility and movement exercises in one intervention group, while Yeung et al. (12) exclusively used stretching, mobility and movement exercises for their entire study, in form of ZTEx. Both studies concluded that stretching, mobility and movement exercises had a significant effect on insomnia symptoms.

Wiklund et al. (18), Suna et al. (16) and Hartescu et al. (17) concluded that a combination of aerobic exercise and resistance training had a significant effect on insomnia symptoms. Passos et

al. (14) compared aerobic exercise and resistance training between intervention groups, but found no significant effect on insomnia symptoms between interventions or compared to controls. Siu et al. (15) concluded that both Tai Chi and a combination of aerobic exercise and resistance training had a significant effect on insomnia symptoms. Siu et al. (15) also found that Tai Chi had a greater effect on insomnia symptoms post intervention compared to the combination of aerobic exercise and resistance training. Insomnia is, as previously explained, a sleeping disorder that mainly influences humans' psychological well-being. And since Tai Chi is a form of exercise used to calm the body and mind, this could be a reason to why Tai Chi had a greater effect on insomnia symptoms than in a more generalized form of exercise. This was the only study including Tai Chi, which means that similar studies would have to be investigated to see if there in fact is a correlation, or if it's coincidental.

Overall, it seems that exercise in general has a positive effect on insomnia symptoms. The studies using a combination of aerobic exercise and resistance training, mostly used this combination within one intervention group. The only study that compared aerobic exercise to resistance training found no significant differences between intervention groups or compared to controls. This means that we can't for sure say if one form is more effective towards insomnia symptoms than the other.

4.2 Short-term effect VS long-term effect

An important thing to notice is that apart from Siu et al. (15) and Wiklund et al. (18), the 6 remaining studies (7,12–14,16,17) didn't report any results for follow-up periods. Consequently, these will only provide short-term effects. This is a slight disadvantage, because it's quite valuable to know if the effects of exercise on insomnia symptoms are persistent. Nevertheless, this isn't necessarily a weakness. The short-term effects could have practical advantages for insomnia-patients. The thought that exercise could have immediate effect and wouldn't require a lot of retention, could help motivate those who suffer from insomnia to exercise. However, there's need for more research on the long-term effects of exercise in insomnia.

4.3 Restrictions

4 studies (15–18) used multiple forms of exercise within intervention groups which could impair the isolated effect of a specific form of exercise. One form of exercise could for instance have a greater isolated effect than the other, which means that we can't know for sure what form of exercise ultimately yielded the greatest effect. One restriction found in D'Aurea et al. (13) is a difference in ISI at baseline between the control group and the intervention groups in ISI at baseline. The largest difference is found between the resistance intervention group and control group, where they differ 4.5 points. In addition, the control group has gone from 16.8 points at baseline to 19.1 points at post-intervention. This contributes to making the already exiting difference even bigger at post-intervention, since the resistance exercise intervention group got a drop of 10.5 in ISI points. More consistent values between the groups at baseline would have given more precisely result throughout the study. The reason to why there was no significant difference between the intervention group performing moderate-intensity aerobic exercise and the control group, may be due to the small sample size of the study (14). This intervention group also had worse baseline variables in all parameters than the other intervention groups and the control group. The fact that this study was conducted over one night highly increases the risk of a nightly sleep variability bias, as we know that people with insomnia has very high variability in sleep for different nights.

Tan et al. (7) and Passos et al. (14) were the only two studies that didn't use total ISI or PSQI score. The available results from these studies were sub scores that match the sub scores from ISI and PSQI, which doesn't provide a satisfying view of the effect of exercise on the whole aspect of insomnia. There could also be some restrictions specifically related to the ISI. The fact that the ISI is more subjective than objective compared to the PSQI, could mean that total ISI score may vary from each participants subjective feeling of how they slept. Based on this, objectively measuring the effects of exercise on sleep could provide a more valid result.

5 studies (12,13,15,17,18) had participants apply to participate, which may indicate selection bias within the studies. This is because applying to participate could lead to motivation within

the selection, which then could lead to a different or even better result than if the recruitment was executed differently. Tan et al. (7) and Hartescu et al. (17) had no specific guidelines for what the controls could or couldn't do during the intervention period. This could make it difficult to know exactly what the intervention groups are compared to. Based on the factors mentioned, it's important to read the studies' results cautiously, as they could contain confounding factors that impair statistical significance.

4.4 Future research

There seems to be quite a lot of research on insomnia and the combination of forms of exercise at different intensities. However, there is lack of research on the comparison and difference between the isolated effect in different forms of exercise, on insomnia symptoms. The cause for this could be that it isn't necessarily different forms of exercise that will be the crucial factor in exercises' effect on insomnia symptoms. Intensity, frequency and duration are the three factors that decides the total effect of exercise (19, p. 9). Therefore, to discover differences in forms of exercise and its effect on insomnia symptoms, there might be a need for more research on the differences between forms of exercise at the same levels of intensity.

5. Conclusion

According to results found in this review paper there is reason to believe that all forms of exercise have a positive effect on insomnia symptoms. The results show that improvements in insomnia symptoms occurs regardless of form, even though improvements seem to be somewhat higher in Tai Chi. Thus, we can assume that improvements in insomnia symptoms concerns more than just the physiological aspects exercise, and that psychological aspects of exercise are of significance too. However, it's difficult to draw any conclusions upon this because there was only one study touching upon the aspects of Tai Chi, in an already small pool of studies with different restrictions included in this review paper. Finding a clear conclusion to what form of exercise yields the greatest effect on insomnia symptoms, will require more research on the correlation between form of exercise and improvements in insomnia symptoms.

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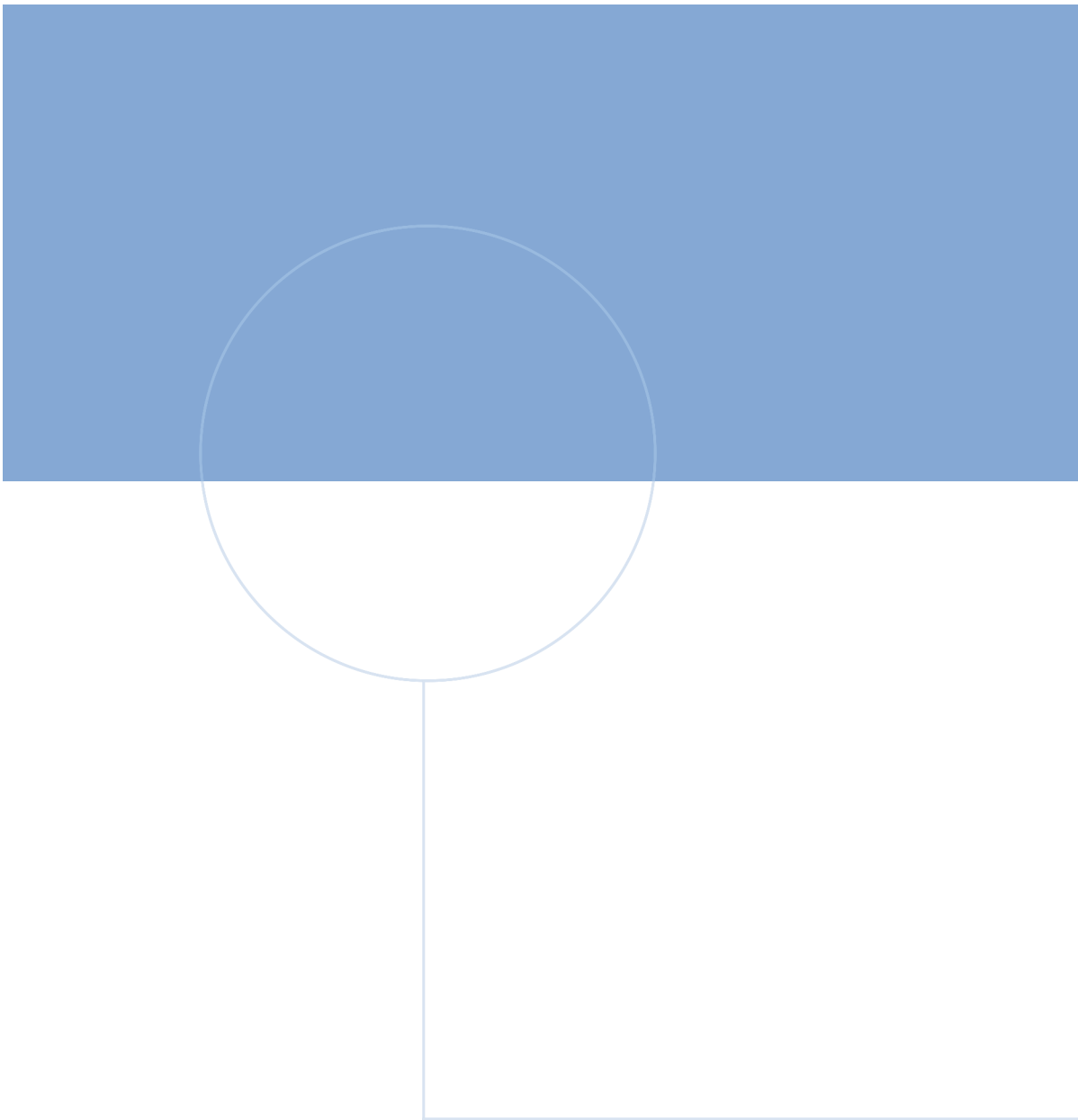

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