THE EFFECT OF EXERCISE AND CIRCADIAN RHYTHM ON WORKING MEMORY IN YOUNG ADULTHOOD

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Thesis for the Master's Program in Experimental Psychology

Graduate School
Izmir University of Economics
Izmir

2023

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A Master's Thesis
Submitted to
The Graduate School of Izmir University of Economics
the Department of Experimental Psychology

Izmir
2023

ETHICAL DECLARATION

I hereby declare that I am the sole author of this thesis and that I have conducted my work in accordance with academic rules and ethical behavior at every stage from the planning of the thesis to its defence. I confirm that I have cited all ideas, information and findings that are not specific to my study, as required by the code of ethical behavior and that all statements not cited are my own.

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ABSTRACT

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Master's Program in Experimental Psychology

Advisor: Prof. Dr. Canan BAŞAR EROĞLU

October, 2023

Working memory (WM) is a central structure with limited storage contains maintaining, updating and manipulating to process of information. Research shows individual and age-related differences and exercise affect WM performance. In addition, circadian rhythm (CR) includes physical, biochemical and behavioral cycles in daily routine. It can affect WM in a positive or negative way depending on how regular or irregular it is. The aim of this research, defining the individual chronotype to find out the optimal time intervals of participants to examine the effect of exercise on WM performance in young adulthood. All schedules (3 weeks skipping rope for experiment group; 3 weeks watching video for control group, also 2 weeks pre and post measurements once a week for both) were planned based upon participants' CR (Experiment Group (10 Neutral Type, 7 Evening Type); Control Group (12 Neutral Type, 7 Evening Type). N-Back Paradigm was applied for 5 weeks totally. A four-way mixed ANOVA was conducted to investigate the effects of chronotype (Evening Type, Neutral Type) and time (base, first exercise, second exercise, third exercise, post) on participants' reaction time (RT) and accuracy rate (AR) depending on N-back conditions (0-back, 1-back, 2-back) in terms of the type of target and non-target separately. The results show that a significant interaction effect was between Time-N-Back-Chronotype on participants' RT. There was a significant interaction effect between Time-N-Back-Group for Target AR and Time-N-Back condition for Non-Target AR. As a results, we obtained in regular exercise enhance WM performance, when CR synchrony effect was considered.

Keywords: Working Memory, Exercise, Circadian Rhythm, Younger Adulthood

ÖZET

GENÇ YETİŞKLİNLERDE, EGZERSİZ VE SİRKADİYEN RİTMİN ÇALIŞMA BELLEĞİ ÜZERİNDEKİ ETKİSİ

ALTUNTAŞ, Kübra

Deneysel Psikoloji Yüksek Lisans Programı

Tez Danışmanı: Prof. Dr. Canan BAŞAR EROĞLU

Ekim, 2023

Çalışma belleği (ÇB), bilginin işlenmesi için depolanması, güncellenmesi ve manipüle edilmesini içeren sınırlı bir bellek alanıdır. Araştırmalar, bireysel ve yaşa bağlı farklılıkların yanı sıra egzersizin de ÇB performansını etkilediğini göstermektedir. Ek olarak, sirkadiyen ritim (SR) günlük rutindeki fiziksel, biyokimyasal ve davranışsal döngüleri içerir. ÇB performansı, kişilerin günlük rutinlerinin düzenli olup olmamasına bağlı olarak da olumlu veya olumsuz değişiklikler göstermektedir. Bu araştırmanın amacı, genç yetişkinlik döneminde yapılan egzersizin ÇB performansı üzerindeki etkisini incelemek, bunun için kronotiplerine bağlı olarak optimal zaman aralıkları belirlenen katılımcılarınla çalışma yapılmıştır. Araştırmanın süreci (3 hafta ip atlama ve ip atlama öncesi ve sonrası olmak üzere haftada bir gün, totalde 5 hafta olmak üzere) katılımcıların SR' ne göre planlanmıştır (Egzersiz Grubu, 10 Ara Tip, 7 Akşamcı Tip; Kontrol Grubu, 12 Ara Tip, 7 Akşamcı Tip). N-Geri Paradigması toplam

5 hafta boyunca uygulanmıştır. Uyaran türü (Hedef, Hedef Olmayan) açısından N-Geri koşullarına (0-geri, 1-geri, 2-geri) bağlı olarak katılımcıların tepki süresi (TS) ve hedef olan ve hedef olmayan uyaranların doğruluk oranı (DO) üzerindeki kronotip (Akşam Tip, Ara Tip) ve zaman (ön ölçüm, ilk egzersiz, ikinci egzersiz, üçüncü egzersiz, son ölçüm) etkilerini araştırmak için iki ayrı dört yönlü bir karma ANOVA yapılmıştır. Araştırmanın sonuçlarına göre, katılımcıların hedef olan ve hedef olmayan uyaranlara karşı verdikleri TS, Zaman-N-Geri-Kronotipler arasında anlamlı bir fark oluşturmuştur. Ayrıca hedef uyaranlardaki DO, Zaman-N-Geri- Gruplar arasında anlamlı bir fark oluştururken, hedef olmayan uyaranlarda yalnızca Zaman- N-Geri arasındaki anlamlı fark olduğu bulunmuştur. Elde edilen sonuçlara göre, SR senkronizasyon etkisi dikkate alındığında ve yapılan düzenli egzersizde ÇB performansında bir artış olduğu görülmüştür.

Anahtar Kelimeler: Çalışma Belleği, Egzersiz, Sirkadiyen Ritim, Genç Yetişkinlik

Dedicated to my loving family

who have given me the unwavering power to pursue my lifelong goals

ACKNOWLEDGEMENTS

In 2014, my psychology adventure started when I saw a psychology laboratory Izmir University of Economics. I decided to being and studying there. So, I started with a huge happiness and curiosity. I knew, I wanted to be experimental psychologist who is conducting research, learning a new program and helping other people with new ideas and techniques. For these reasons, I am in here where I want to be. Also, the process is special for me.

During my undergraduate and graduate, I met lots of precious lecturers. I took their lessons, conducted research with them. Lesson that I took and my internships showed me what should I do.

Firstly, I would like to show my gratitude to my supervisor Prof. Dr. Canan BAŞAR EROĞLU for helping, guiding and supporting me in critical times. I learned and I am going to learn lots of thing about lessons and life. I admire her because of energy, enthusiasm and knowledge. I am so glad to know.

Secondly, I would like to express my thanks to my advisor Prof. Dr. Seda CAN during undergraduate and graduate, for her encouragement, helping and patience. I leaned lots of thing about statistics and research. I know her since I begin undergraduate. I inspire her perseverance about education.

I am also more thankful to jury members Asst. Prof. Dr. Emel ERDOĞDU and Prof. Dr. Falih KÖKSAL for their constructive feedbacks, encouragement to this research field and valuable contributions. Their insightful suggestions have greatly improved my future ideas on this research.

Furthermore, I would like to thank Kurtuluş Mert KÜÇÜK for technical and academic support and cooperation to software program. Another thanks to Ilgım HERDARCAN SEZEN to answering my lots of questions about structure of paradigm and other lots of my questions. Merve BULUT and Günce YAVUZ ERGİYEN gave me kindly support during my thesis induced problems and my poster presentations, Ezgi PALAZ supported me finding participations part and demonstrated shortcuts made easily. Last but not least, I would like to thank Zehra ÜLGEN who is my friends since undergraduate. She had supported me during data analysis and her encouragement to my whole thesis process and my academic process. She has unwavering belief in my abilities. All of them are amazing people and I am grateful for their encouragements, suggestions, helps.

I have a beautiful family. They are keystone in my life. When I am upset, all of them turns to sunlight and I feel their love every time and everywhere. I have huge love, missing and gratitude towards my mother Sermin ALTUNTAŞ and my father Alaattin ALTUNTAŞ. They are my magic power. My brother Serkan ALTUNTAŞ is my superhero, I helped my every project. He gives amazing ideas and we success everything. My sister Sibel AĞDEMİR is super women. She overcomes towards challenge. She always listens to me and helps me. My nephews Eymen and Emre AĞDEMİR and my niece Ece ALTUNTAŞ are my source of inspiration. They are so intelligent and they have infinite curiosity. I love all of them.

If I write all my friends names in here, this pages not enough. I glad to meet them. I feel their supports, friendships. A bigger thanks for them.

Lastly, there is no doubt that I am lucky and that I was able to meet them all people in my life. I believe that I have some different beauties in my life. All of them are lighthouse for me in the shadows. I believe, if person still breathes, hope is always in there. I would like to thank you myself, to keep going and never give up.

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LIST OF ABBREVIATIONS

AC Accuracy Rate

CR Circadian rhythm

WM Working Memory

PC Parietal cortex

RT Reaction Time

PE Physical exercise

PFC Prefrontal cortex

VPC Ventral parietal cortex

CHAPTER 1: INTRODUCTION

1.1. Working memory

Since its beginning in the 1960s, working memory is captured the attention of academics' sciences (Baddeley, 1974; D'Esposito and Postle, 2015). In fact, despite over a century of research in the domains of psychology, neuroscience there is still no universally accepted classification of memory, particularly in terms of its functions and mechanism (Baddeley, 2010; Cowan, 2005; Cowan, 2008). Nevertheless, it is generally accepted that working memory is crucial to execution of goal directed behaviors in which information must be retained and manipulated. A person's ability to simultaneously manage certain information while still maintaining of other information is known as WM (Baddeley, 1996; Miyake, 2001; Engle and Kane, 2004). Over the course of the day, people have keeping in mind lots of critical information briefly, such as road directions, tip calculation, remembering the phone numbers. Working memory (WM) provides holding, using, solving the information and erasing them when other information comes like a blackboard in the mind. For instance, when we instruct student on how to solve a mathematical problem they think and repeated in their minds in a short-term manner. After that, when student see the problem, follow the instruction and solve it, so the students' working memory process is activated. Working memory functions consist of limited active storage, maintenance and manipulations of information to retrieve it a short period of time (Kane and Engle, 2002). As looking at the history of working memory model posited and developed different from the short-term memory in 1974 and the model has been expanded and refined (Baddeley and Hitch, 1974; Baddeley, 2000). The Baddeley and Hitch model indicated that WM is a multicomponent system and WM includes control and storage system into works each other interactively. The first model contains three subcomponents that are phonological loop, visuospatial sketchpad and central executive functions occurs comprehensive space in Figure 1. The first is the phonological loop system as a phonological store that include sounds which reflect shortly before fading away and updating the information about phonological store is articulatory rehearsal. The system is based on verbal working memory.

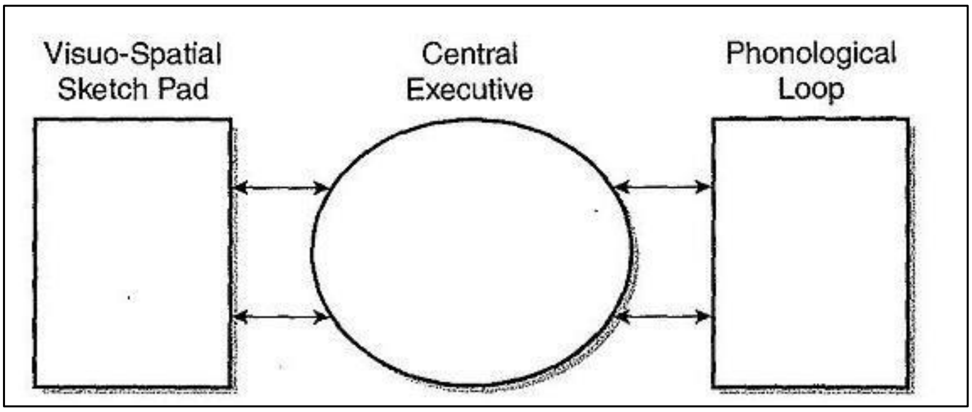

Figure 1. Baddeley model of Working Memory (Source: Baddeley, 1986).

The second component is the visuospatial sketchpads that are divided into two distinct systems. There are two systems involve in maintaining representation of visual objects and spatial representation. Last and crucial component is central executive part that is the centre of control for working memory model. It is responsible for coordinating and managing the information through to inside the WM system (Cowan, 1999). The central executive directs cognitive functions, distributes attentional resource and regulates how the other working memory units interact with one another (Baddeley and Hitch, 1974; Baddeley, 2000). Even though there is still much to learn about the specific structure and operation of the central executive, it is widely understood to be have an important role in some following process like attentional control, cognitive flexibility, inhibition, integration and coordination and cognitive planning. Moreover, central executive also activates long term memory (Baddeley and Hitch, 1974; Miller et al., 1960; Cowan, 1999). In 2000s, episodic buffer is added subsequently part of the Baddeley model of WM. It is responsible for storing that uses multiple components to coordinate the memory with long-term integration between different types of information from internal and external part (Baddeley and Logie, 1999; Baddeley, 2000) in Figure 2.

WM is regarded as an essential key cognitive function because it enables to maintain brain's capacity for temporary storing, retaining, modifying information simultaneously. In the human brain, frontal and parietal networks is linked to WM (Ku, 2019). The prefrontal cortex (PFC) is centre area for WM. PFC link with executive control, attentional process and coordination of information. WM performance is correlated with different types of stimuli that are activity in a wide range of brain areas. On the other hand, there are similarities between these areas during the WM tasks.

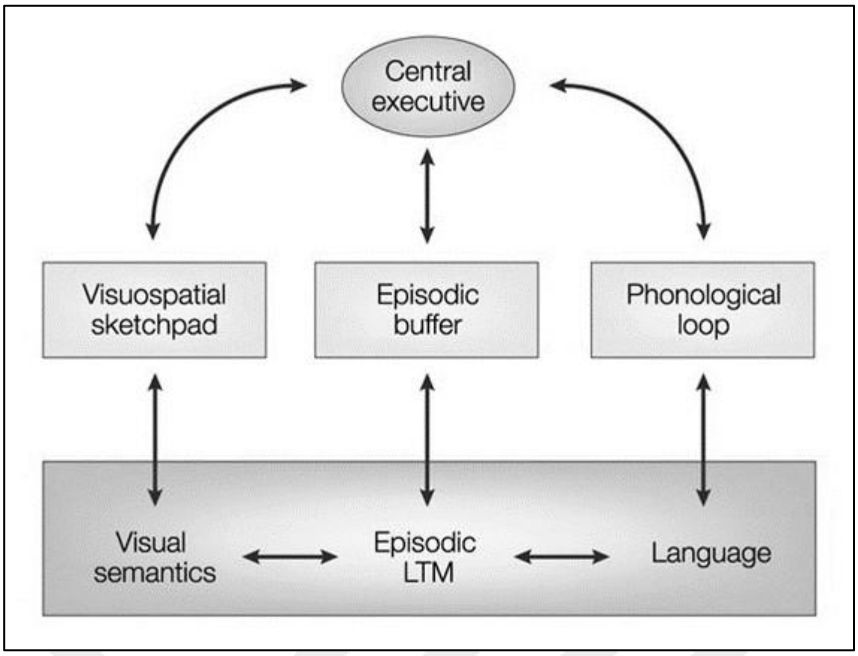

Figure 2. Baddeley new model of Working Memory (Source: Baddeley, 2003).

The most common activity is shown a fronto-parietal network, frontal regions with caudal part of the superior frontal sulcus, middle frontal gyrus and inferior frontal gyrus (Rottschy et al., 2012; Nee et al., 2013). For example, the prefrontal cortex is considered in cognitive flexibility and attentional and inhibitory control and coordination and updating of information with dorsolateral prefrontal cortex. The parietal cortex (PC) is responsible for spatial working memory, includes to maintain and manipulation of spatial information like mental rotation, remembering information, navigating road by posterior parietal cortex (PPC). Moreover, ventral parietal cortex (VPC) is implicated in both retrieval of the object related information and supporting the storage. Auditory and verbal WM process is associated by the temporal cortex as known both superior temporal gyrus and the inferior frontal gyrus. These regions are engaged in encoding, maintenance and retrieval of verbal information. Medial temporal lobe and hippocampus is mostly associated with long term memory and working memory. In addition, association between WM and white matter are still unclear to determined specific local in the brain like inferior, posterior, anterior or superior. However, Veltman et al. (2003) and Nagel et al. (2011) researched brain activation in the demanding WM situations by fMRI. They found that white matter connectivity to integration between further regions. Also, dopamine (DA) represents a critical role in WM (Brozoski et al., 1979; Landau et al., 2009). It relates with white matter integrity (Rieckmann et al., 2016).

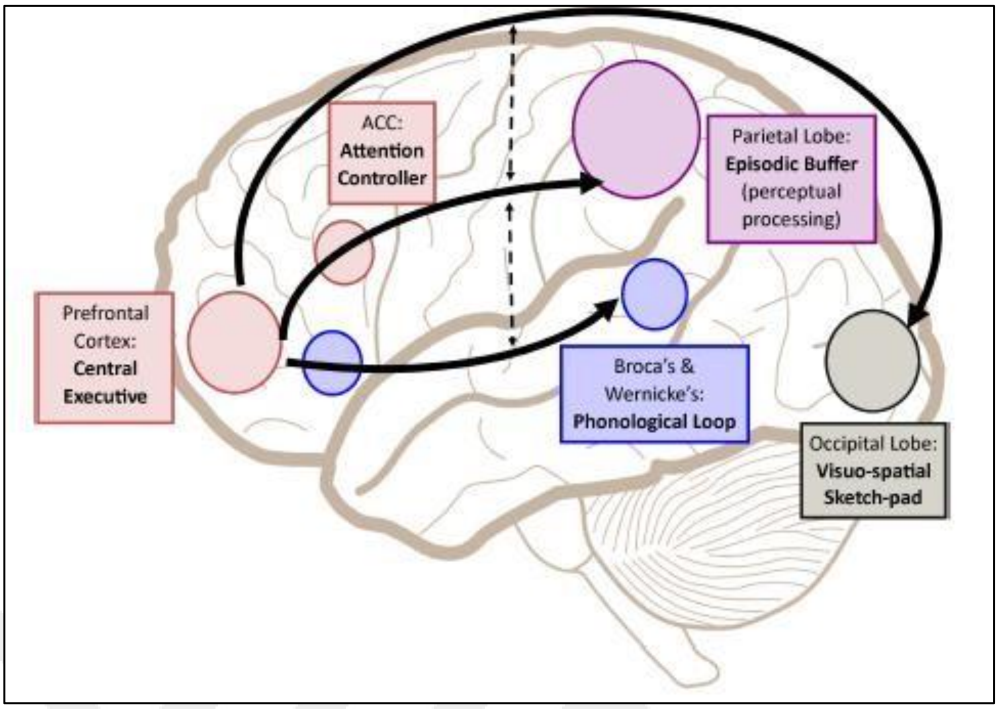

Figure 3. An illustration of the central executive in the brain as a means of controlling and overseeing the manipulation of incoming information (Source: Baddeley, 2010; Chai et al., 2018).

In recent research on working memory process looked for existing and functions of central executive. Updating information is replaced to old, stored information, it is also expanded by new information. These new forms of information and old ones is protected the maintenance in the relevant unit in stable. (Ecker et al., 2014). Although lots of updating, maintenance and manipulation of information on working memory, it has a limited storage as a known. However, working memory capacities might change. This changing is affected by individual differences that is influenced accessibility of representation, distraction or interference, attention, suitability of tasks or situations, suppressing inappropriate thought and behaviours (Rosen and Engle, 1998).

1.1.2 Working Memory and Age

Working memory capacities are important point to sustaining life an effective way. From to child to older adulthood, deficiency and impairment in working memory and executive or cognitive functions play critical role in human life. Aging is directly influenced WM performance in cognitive capacities. With ages, working memory performance declines (Babcock and Salthouse, 1990; Salthouse, 1994; Paxton et al., 2008; Ziaei et al., 2017). Bopp and Verhaegen (2007) reported that between WM and age has a negative correlation. Additionally, WM rises linearly until adolescence, although there is no change in core structure of the components during the process (Lambek and Shevlin, 2011). According to Borella et al., 2008, the decrease observed to be linear with continuous and constant rate of decrease beginning in the 20s and without any sharp decrease in older age. Some longitudinal studies show that consistent decline in WM performance with aging (Chiappe et al., 2000; Park et al., 2002). They also showed that older individuals' capacity achieved 74% of younger individuals' capacity when they are doing complex span task which needs both passive and concurrent active processing (Bopp and Verhaegen, 2005). Additionally, decreasing of visuospatial working memory is more than verbal working memory in age related. Visual working memory capacities in 55 years old adults decreased rapidly, when it is compared with 8 years old children (Brockmole and Logie, 2013). Older participants had a lower perform on working memory task when making a comparison with younger participants (Nissim et al., 2017). Older adults showed declined modulation of task difficulty, it reflected to falling task performance (Rieck et al., 2017). However, in verbal working memory capacities and performance are closed between 20-yearolds and 70-year-olds. People who are between 5 and 19 years, has critical increased in working memory performance and at 30 years old, these capacities have a highest working memory performance. (Alloway and Alloway, 2013).

Working memory plays a crucial role in age differences in cognition according to literature, a lot of studies have found that young adults perform better when conditions in task increase the demands on WM **(**Salthouse, 2015). Salthouse, Mitchell and Palmon (1989) are reported that a spatial integration task has no age difference, but older adults were less accurate than the younger adult. In the other study, they used to maintain of information during the performance task for age-related difficulty. In either situation the failure to preserve relevant information while processing of the other information is consistent with the failure of WM. Some researcher have used the different task like N-back for the investigation of the age-related differences in WM performance. Salthouse, Atkinson and Berish (2003) found that significant age defences between young adults and older adults in updating, maintaining task. Mostly, younger adults had more accurate than older adults. Another study shows that a task difficulty increased, older adults (55-69 years) demonstrated decreased brain activation compared to middle- aged adults (35-54 years), whereas less deactivation was investigated between younger adults (20-34 years) and middle-aged adults (Rieck et al., 2017). As a consequence, this research revealed that cognitive function variation across the life span at the neurobiological level, the brain's diminished ability to modulate functional regions to increase difficult with age (Rieck et al., 2017).

1.2. Exercise

Physical exercise (PE) that involves planned, systematic and repetitive bodily movements that improves and maintains one or more component of physical fitness (Piercy et al., 2018). According to wide range of research fields indicated that the brain might be change by the physical activity potentials as external factor (Erickson et al., 2015). Especially, even if single session of PE can temporarily change in cognitive abilities (Chang et al., 2012; Verburg et al., 2014). A physical inactivity in lifespan is associated with worse physical and psychological- cognitive health (Tremblay et al., 2011). Over the last decade, effect of exercise has increased an interest on cognitive performance. Exercise encourages nervous system, plasticity and protection (Zigmond and Smeyne, 2010) improves memory acquisition (Winter et al., 2007) and motor cortex plasticity (Cirillo et al., 2009) and prevents age-related cognitive dysfunction such as dementia, Alzheimer (Etgen et al., 2010; Podewils et al., 2005).

1.2.1. Working Memory and Exercise

McMorris and Hale (2012) reported that aerobic exercise is emphasized as an efficiency strategy to positively affect executive control during and after the exercise (Chang et al., 2012). In recent research, acute and chronic of physical activity and exercise might impact executive process such as WM, cognitive flexibility and control of inhibition (Rathore and Lom, 2017; De Greef et al., 2018). Exercise divided in acute and chronic exercise because of duration. Acute exercise consists of a single session of exercise, whereas chronic exercise is prolonged and repeated long period of time Cognitive performance is influenced by acute and chronic exercises (Piercy et al., 2018). Types of exercises and duration of exercises are also affected to working memory in a different way. In previous research showed that acute exercise (AE) influenced post exercise memory slightly (Tomporowski and Ellis, 1986). In contrast, latest research indicated that memory encoding and consolidations are improved by acute exercise (Loprinzi et al., 2019). On the other hand, chronic exercise (CE) has more beneficial effect than AE even short- and long-term memory and working memory performance (Etnier et al., 1997; Roig et al., 2013; Rathore and Lom, 2017). Human motor system is made great contribution from WM. When AE contribute neuroplasticity changes in memory process, CE is better for long term adaptation that leads to change hippocampal volume (Loprinzi et al., 2021). If people do automatic and same routine of exercises, the necessary of working memory decreases in the progress of time such as swimming, running and cycling (Wood et al., 2020). WM needs new challenging learning technique to improve and provide new connection in brain. Aerobic and anaerobic exercise help to ensure (Hargreaves et al., 2020). Because of that, in healthy children, younger and older individuals, influenced executive functions with aerobic exercise (Chaddock et al., 2011).

Age is a crucial effect of exercise on memory. Latest research shows that acute exercise might be repair in older adults and in WM, AE may enhance memory across the adult lifespan (Loprinzi et al., 2021). From childhood and adolescence, executive functions improve (Zelazo and Müller, 2002) and followed by decrease from early and late adults (Mayr et al., 2001). Higher order executive function is influenced by ceiling effect occurs even participants with low performance on task exercise a single aerobic exercise (Drolette et al., 2014; Sibley and Beilock, 2007).

1.3. Circadian Rhythm

Circadian rhythm (CR) represents biological cycle in wide range of living systems such as bacteria or human (Bell-Pedersen et al., 2005). The rhythm consists of daily sleep and awake cycle in 24 h. They are regulated by an endogenous circadian pacemaker located in the superchiasmatic nucleus of the anterior hypothalamus (Borbély, 1982). During the biological day, the action mechanisms of these rhythms cause a wake promoting drive that balances the effect of accumulated homeostatic sleep pressure (Reichert et al., 2017). The sleep and awake cycle are affected by different types of neurochemical and hormones like cortisol and melatonin (Schmidt et al., 2007). Not only sleep and awake cycle, physical activities, eating and daily routine are affected to regulation for circadian rhythm. It includes physiological and behavioral process. Hormones, homeostasis, body temperature and cell cycle changing regulated by circadian rhythm.

Individual differences represent 'Chronotype' in circadian rhythm. Chronotype means that difference of circadian rhythm changes from person to person. Horne and Östberg developed Morningness and Eveningness of Questionnaire (MEQ) in 1976. MEQ which is used frequently, includes 19 items. According to scores, people are in between 59 and 86 - morningness; between 42 and 58 – neutral type; between 16 and 41- eveningness (Horne and Östberg, 1976). When morningness types are waking up and sleeping early, doing their work, physical exercise in morning time, eveningness type are waking up and sleeping lately, spending their time between afternoon and night. Neutral types have mostly changeable character in circadian rhythms. When looking at from past to now, biological changing cause changing for circadian rhythm because of the modern life standards (Takahashi et al., 2008). Alteration of circadian rhythm leads to occur more neutral types. In adulthood populations has approximately, 60% neutral, 40% morningness and eveningness types (Horne and Östberg, 1976; Adan et al., 2012). In childhood and older adulthood, people tend to be morningness, but eveningness prevail among adulthood (Fisher et al., 2017; Randler et al., 2017).

Individual variations cause difference of cognitive and behavioral performance in circadian rhythm. The three types of chronotype have a unique highest level of different performance in daily cycle. The synchrony effect explains optimal time of the day in task performance as morningness in morning time, eveningness in evening time. Neutral types have more flexible for synchrony effect.

The researched conducted on mice is demonstrated that exercise restored circadian rhythm that includes activity, heart rate and body temperature (Schroeder et al.,2012). Moreover, human investigation has shown that the resistance and endurance exercise provide the expression of core clock gene. As a result of this findings indicate that exercise effect circadian time signal and alters the phase of the molecular clock, mostly peripheral tissues. These process still unclear (Dickinson, 1985; Zambon et al., 2003).

The literature that investigated that the relationship between physical exercise and executive function mostly studied on the elderly population because cognitive and executive function decreased (Angevaren et al., 2008). Children are also investigated because human brain is continuing improvement (Fedewa and Ahn, 2011). Therefore, in this thesis, young adults are selected due to peak of the brain maturation. If exercise has beneficial effect for executive function and WM in young adults, it would be encouragement for people. Therefore, having information about circadian rhythms makes easier to understand the relationships between circadian rhythms and those physiological and behavioral processes.

1.3.1 Circadian Rhythm and Working Memory

Circadian rhythm and working memory relationship is less researched. Integration of circadian rhythm and homeostatic balance regulated daily oscillation in working memory. However, investigation findings are not homogeneous in working memory daily (Monk et al., 1997; Könen et al., 2015; Nasiri et al., 2018). Neutral types of cognitive performance decline night and early morning, their optimal performance time between 4 pm and 10 pm or between 11 am and 2 pm (Valdez et al., 2012; Valdez et al., 2014). When age related sleep cycle is taken account, circadian rhythm and working memory performance change. In younger adulthood, cognitive performance increase, when comparing the older adulthood (Yoon et al., 1998). Evaluation of preschool children' working memory performance in daily pattern at 8 am, because these ages have morningness type (Nasiri et al., 2018). In contrast, in younger adulthood performed at 3 – 4 pm in working memory task performance. Both have different circadian rhythm tendency in same task (Foster and Roenneberg, 2008). As a result of this, after individual's difference measured and then physical and cognitive performance task should have applied on them.

1.4 The Present Study

The primary aim of this thesis was to evaluate the effect of exercise and circadian rhythm on WM performance in young adulthood. Within this respect, each participant' optimal time and exercise effect of N-back WM paradigm was evaluated to comparing skipping rope exercise group and control group who were watch video as psychology documentaries. In this regard, the ideal time and exercise impact of the N-back WM paradigm for each participant were compared to the skipping rope exercise group and the control group who watched video as psychology documentaries. Skipping rope is selected for exercise. The reason for that in the moderate- intensity exercise and higher consumption oxygen level might be provided by skipping rope. It can enhance the coordination of multiple muscle that is involve upper and lower synchrony, but timing and position is more critical. Moreover, it works with most muscle during the exercise and consuming oxygen provide to turns out the protein release. Therefore, this process contributes WM performance. Furthermore, exercise modulates the molecular clock in skeletal muscle by affecting both the amplitude and phase of circadian rhythms. Also, affects monoaminergic activity related to cognitive performance. Likewise, this study seeks to determine whether there were any variations in the impact of chronotype on WM performance, with a special emphasis on understanding young people. WM performance was compared to skipping rope one day a week for three weeks and viewing documentaries one day a week for three weeks at the participant's preferred time.

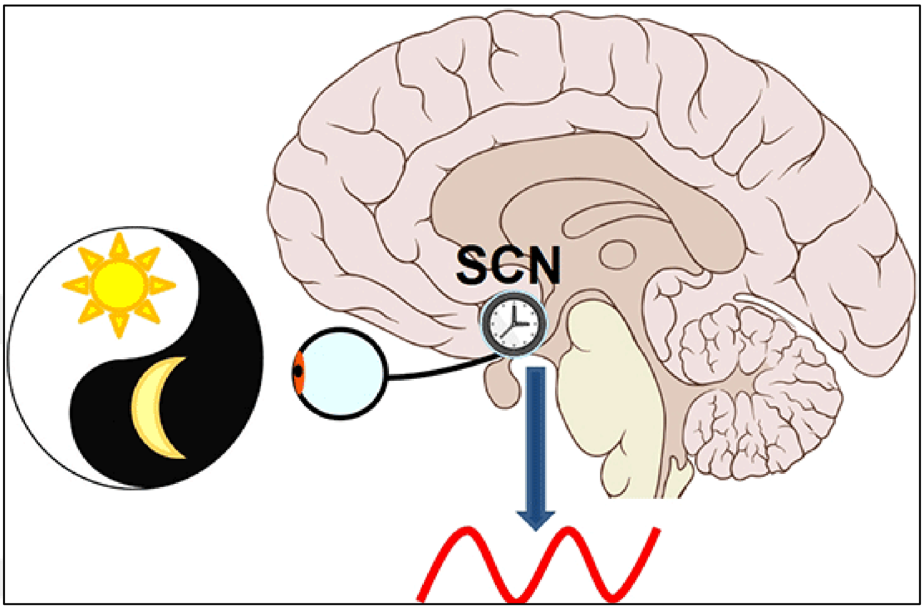

Figure 4. An illustration of the superchiasmatic nucleus (SCN) regulates the circadian rhythm (Source: Cao, 2019).

CHAPTER 2: METHOD

2.1. Participants

Thirty-six healthy younger adults (*M*=21,61, *SD*= 2,54) participated in experiment. The power analysis was performed using G*Power (3.1.9.7 Version, it is a tool for computing statistical power analyses) that determine adequacy of sample size. All participant received instructions from the experimenter. Some of the participants were chosen from Introduction to Psychology, they received an extra course credit for their participation. Before the experiment, participants were fulfilled informed consent forms (Appendix A; A.1) and various online questionnaire to confirm that all participant matched the research inclusion criteria. Participants criteria of the study were determined as: (1) being between the ages of 18-30 years old, (2) not having vision problems (3) not having athletic background, (4) not doing active aerobic exercises in the last two years. (4) The most important thing is that participants do not have any obstacle doing exercises. (5) Also, none of the participants reported to using any medication for neurological or psychological during the experimental sessions. (6) The Richards-Campbell Sleep Questionnaire score must be above the 60**.** Participants who did not meet the inclusion criteria, were bring someone else who meet the participation criteria. In total, 6 participants excluded (4 in experiment group, 2 in control group) to study because two participants leave because of lecture drop out, one participant excluded due to very lower scores and one is only one person with morning types and lastly two of them had lower score from Richards-Campbell Sleep Questionnaire. The research procedures approved by the ethical committee of Izmir University of Economics (28.02.2023). (Appendix H)

2.2. Materials, Stimuli, Apparatus

2.2.1 Materials

2.2.1.1 Demographic Form:

All participants' age, sex, education, weight and height, having physical or neurological disease, use of medications, consumption of alcohol and cigarette, doing physical exercises are all questioned on this online form. (Appendix B)

2.2.1.2. Edinburgh Handedness Inventory:

Participants fill out the Edinburg Handedness Inventory that was developed by Oldfield (1971). The inventory modified by Geschwind and Behan (Geschwind and Behan, 1982). The questionnaire includes 10 types of items (writing, drawing, throwing, scissors, toothbrush, knife, spoon, broom, striking a match, opening a box) which hands the most prefer to use during these activities. The total scoring in five categories; 'always right hand', 'usually right hand', 'use both hand', 'usually left hand', 'always left hand'. The answer to each question with +10, +5, 0, -5, - 10 points. The scores are between +100 to -100. The dominant right hand scored between +80 and +100, the non-dominant right hand between +20 and +75, using both hand between -15 and +15, un-dominant left hand between -20 and -75 and the dominant left hand between – 80 and -100 (Tan, 1988). (Appendix C)

2.2.1.3. The Physical Activity Readiness Questionnaire (PAR-Q):

The original questionnaire in Canada to easier evaluation for person participating in the Canadian Home Fitness Test was recommended. Chisholm and colleagues developed PAR-Q about that time for Ministry of Health (Chisholm et al., 1975; Chisholm et al.,1978). The PAR-Q improved by Shephard in 1991. Millions of individuals complete this questionnaire. The total question is seven and people answer that 'yes or no'. If all answer is 'Yes', people have a fitness appraisal with doctor. If all answer is 'No', person begins exercises slowly and sets up gradually. Turkish version of the PAR-Q adapted by Ertekin (2018). (Appendix D)

2.2.1.4. Sleeping Questionnaire:

The participants responded to sleep questionnaire subjectively to determine sleep and awake time regulations of time. There were nine questions designed to assess sleep related daytime. These included waking up time, getting up time, feelings about sleep, daily and weekly sleep time. (Appendix E)

2.2.1.5. Morningness - Eveningness Questionnaire (MEQ):

In 1976, Horne and Östberg was developed the morningness and eveningness questionnaire. The questionnaire that is a self-evaluation, consist of 19 questions that ask participants about their daily routine, sleep patterns and performance. The chronotype characteristics of each participant are determined. The overall score ranges from 16 to 41 means 'Evening Type', from 42 to 58 means 'Neutral Types', from 59 to 89 as 'Morning Type' (Horne and Östberg, 1976). The version reliability and validity of Turkish version was conducted in 2005 by Pündük et al. (2005). (Appendix F)

2.2.1.6. The Richards-Campbell Sleep Questionnaire (RSCQ):

Richards developed the RSCQ scale in 1987. It is a six-dimensional and self-report scale. The five items consist of sleep depth, sleep latency, frequency of awakenings, sleep efficiency and quality. These items include the total score but sixth item that is about noise is not included in total score (Richards, 1987). If score of 0 to 25 that means 'very poor sleep' and a score of 76 to 100 is 'very good sleep'. The participant' scores increase, sleep quality improves. In 2010, Turkish adaptation, validity and reliability conducted by Özlü et al. (2015). (Appendix G)

2.2.2. Stimuli

2.2.2.1. N-back Paradigm Stimulus

As a paradigm for studying the working memory, the N-Back paradigm is well appropriated to both process specific and domain specific perspective (Awh, 1996; Braver et al., 1997). N-back paradigm is presented to participants; each stimulus comes certain sequence. The participant decides to about stimuli through each set of instructions. For instance, in the letter 0-back condition, any disclosure of predetermined target that responded by participants. In the 1- back condition, participant answers if current stimulus matches the previous one; and in the 2- back condition, participant's replies if the current stimulus same as the two letter earlier. This paradigm used to attention and compare situations that maintain is required previous one conditions. Moreover, 2-back conditions contain both maintenance and manipulations for working memory. Some N-back paradigm includes types of lures because of occurring working memory load in stimuli. For example, in 2- back condition postlure target that can be used (e.g., T-T-T in 2-back condition, third T is the postlure target).

In my thesis, six phonologically distinct letters that is uppercase consonant sequence used as stimuli (*C, H, M, R, T, Y*). Each letter repeats five times between blocks. Experiment has three stages, each stage has 0-back, 1-back, 2-back conditions. Each condition (0-back, 1-back, 2-back) contains three blocks that have pseudorandom order in each block for total of 270 stimuli. Each block has 10 targets and 20 nontargets. Also, N-Back paradigm has three trials includes three N-back conditions, which 0-back, 1-back, 2-back, but sequence of second and third stage are different due to avoiding bias in within design. As a result, each participant was shown 9 N-back conditions with 3 trials. Stimuli length is 500 ms and inter stimulus interval length is 2000 ms and fixation cross length is 250 ms between stimuli. All stimuli were presented in white ink at the center of the screen and grey background. The condition sequence is in Figure 3.

Participants press the two keys on the keyboard (‘F’ and ‘K’ keys) in Figure 4. ‘K’ is representing target stimulus and ‘F’ represent non-target stimulus. In the 0-back condition, (i.e., target letter was ‘C’ for first trail, ‘M’ for the second trail’, and ‘R’ for the third trails) participants must press the keyboard ‘K’ letter with their right index finger when they see the letter specified in the instruction on the screen. On the hand, participant must press the keyboard ‘F’ letter with their left index finger when they do not see the specific letter. In the 1-back condition, participants must press the keyboard ‘K’ letter with their right index finger when they see on the screen is the same as the letter previous one. In contrast, participant must press the keyboard ‘F’ letter with their left index finger when they see different letter from the previous letter. In the last condition is 2-back, participants must press the keyboard ‘K’ letter with their right index finger when they see on the screen is the same letter as the two-letter previous ago. In contrast, participant must press the keyboard ‘F’ letter with their left index finger when they see different letter from the two letters earlier.

As consequences of that, stimulus presentations consist of the three trials and each of them included three N-back conditions. As part of the second and third trials, the presentation order of the N-back conditions were randomized based on the Latin Square experimental design; the order of the N-back conditions were randomized based on the Latin Square block design. Nevertheless, all participants were exposed to 0, 1, 2-back conditions respectively, in the first trial. In Latin Square design, were occurred 5 different presentations and all of them generated second and third tails. (A: 1-,2-,0-back; B: 1-,0-,2-back; C: 2-,0-,1-back, D: 2-,1-,0-back; E: 0-,2-,1-back). All participant has own Latin Square design, balance in Table 1.

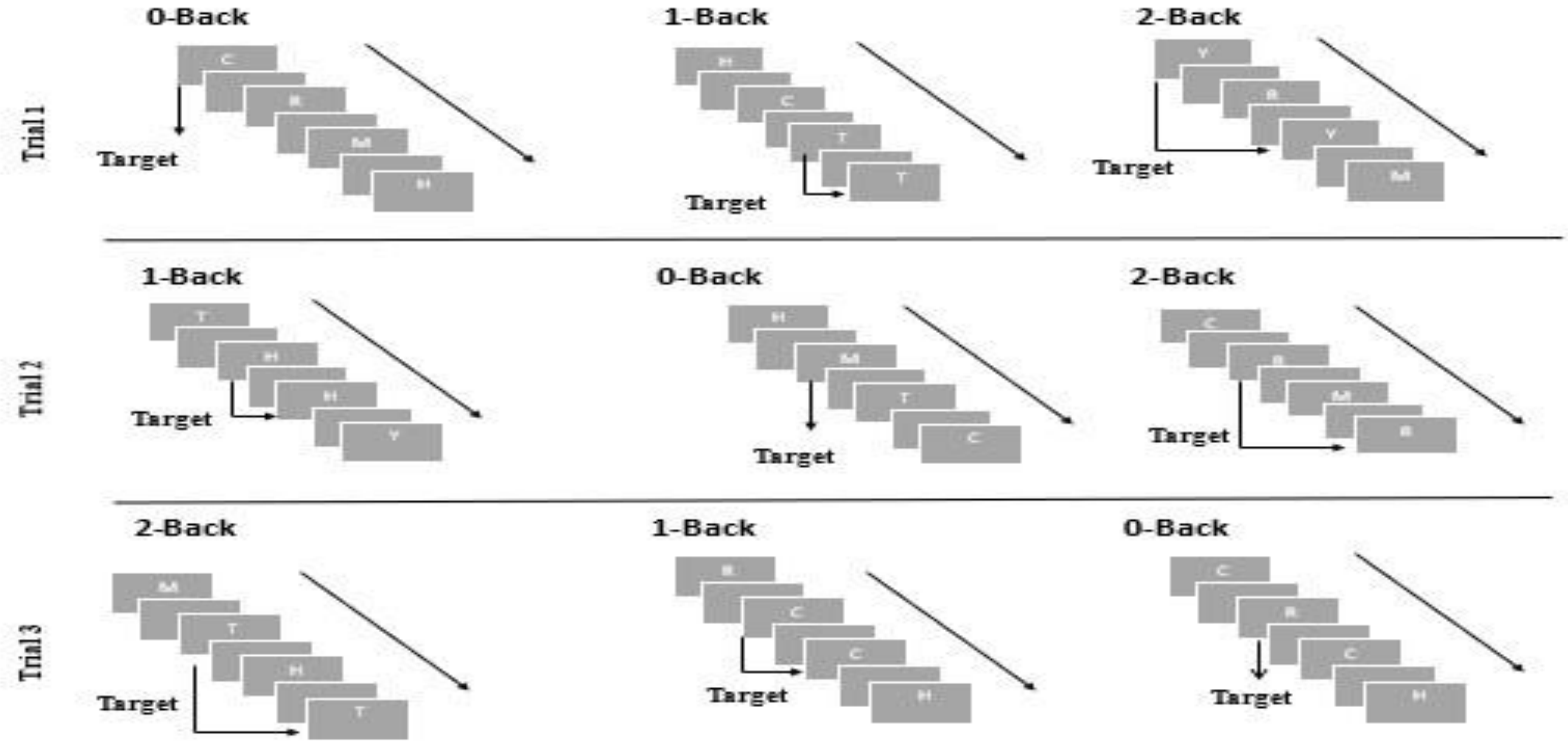

Figure 5. Schematic illustrations of stimuli and trials in N-back paradigm

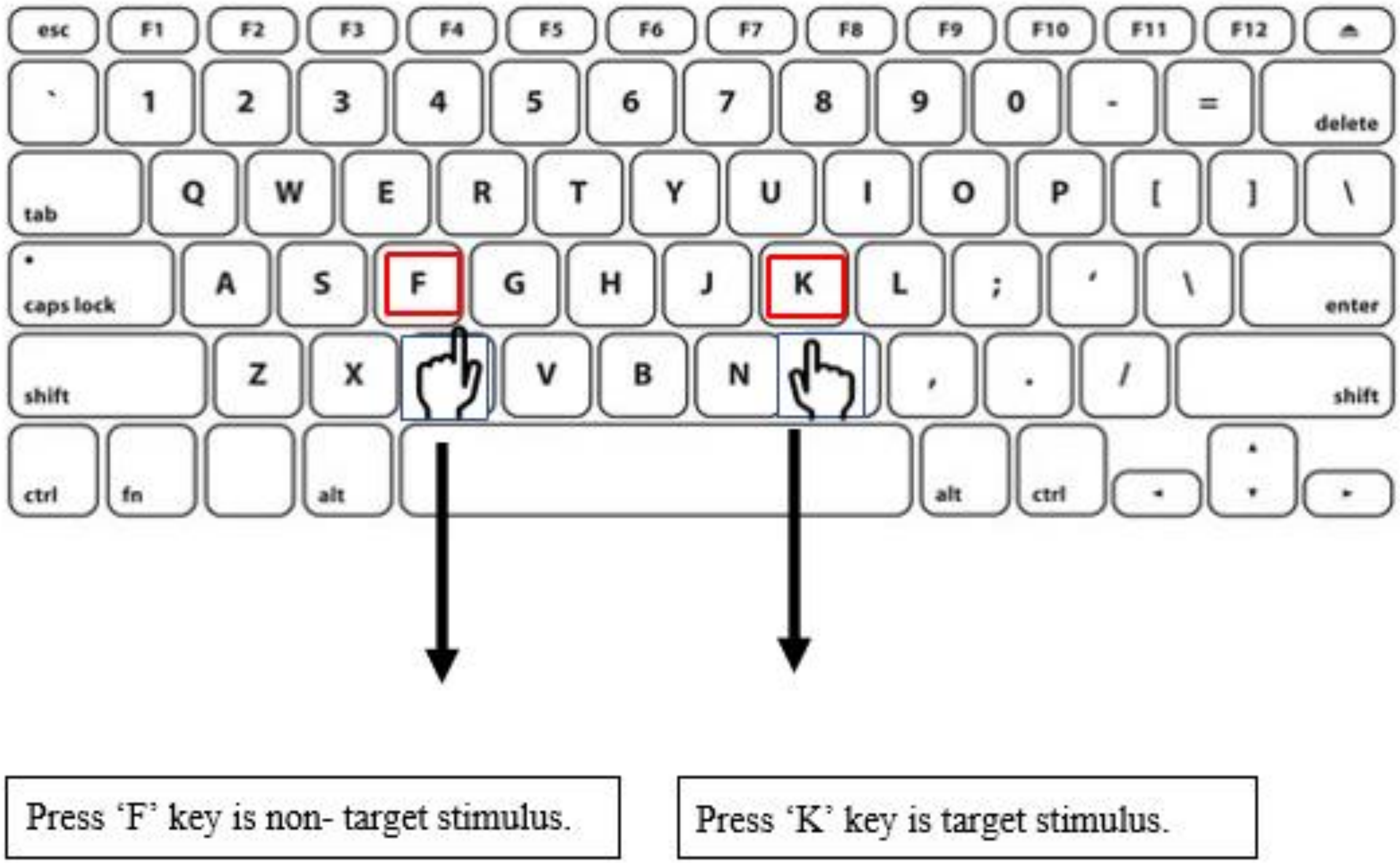

Figure 6. Presentation of the button press of the stimuli.

Table 1. Latin Square Randomization of N-back Conditions Design for Trail 2 and Trail 3.

Participant	Trial 1			Trial 2			Trial 3		
1	0	1	2	1	2	0	0	2	1
2	0	1	2	0	2	1	2	0	1
3	0	1	2	0	2	1	1	0	2
4	0	1	2	1	0	2	0	2	1
5	0	1	2	0	2	1	1	2	0
6	0	1	2	0	2	1	1	0	2
7	0	1	2	1	2	0	2	1	0
8	0	1	2	1	0	2	1	2	0
9	0	1	2	2	1	0	2	0	1
10	0	1	2	2	0	1	1	2	0
11	0	1	2	2	0	1	2	1	0
12	0	1	2	1	0	2	0	2	1
13	0	1	2	0	2	1	1	2	0
14	0	1	2	1	2	0	2	1	0
15	0	1	2	2	0	1	1	2	0
16	0	1	2	0	2	1	2	1	0
17	0	1	2	0	2	1	2	0	1
18	0	1	2	1	2	0	2	0	1
19	0	1	2	2	0	1	0	2	1
20	0	1	2	1	0	2	2	0	1
21	0	1	2	1	2	0	1	0	2

Table 2. Latin Square Randomization of N-back Conditions Design for Trail 2 and Trail 3.

Participant	Trial 1			Trial 2			Trial 3		
22	0	1	2	2	1	0	0	2	1
23	0	1	2	2	0	1	2	1	0
24	0	1	2	1	2	0	0	2	1
25	0	1	2	1	0	2	2	1	0
26	0	1	2	0	2	1	2	1	0
27	0	1	2	1	2	0	1	0	2
28	0	1	2	2	1	0	0	2	1
29	0	1	2	1	2	0	2	0	1
30	0	1	2	2	1	0	1	2	0
31	0	1	2	2	1	0	1	0	2
32	0	1	2	1	0	2	1	2	0
33	0	1	2	1	0	2	2	1	0
34	0	1	2	2	1	0	1	0	2
35	0	1	2	2	1	0	1	2	0
36	0	1	2	2	1	0	2	0	1
37	0	1	2	2	0	1	1	0	2
38	0	1	2	1	0	2	2	0	1
39	0	1	2	2	0	1	0	2	1
40	0	1	2	2	0	1	1	0	2
41	0	1	2	1	2	0	0	2	1
42	0	1	2	1	0	2	2	0	1

2.2.3. Apparatus

2.2.3.1 Stimulus Presentation

All the stimuli were prepared in each block separately by using Microsoft Office 365, Excel program. After that each block was chosen by using PsychoPy 2022.2.4 program in its own counterbalance. Instruction of N-back conditions and time prepared at PsychoPy 2022.2.4. N- paradigm presented to participants via desktop (TOSHIBA PC/ 2.40 GHz/ 4GB RAM/ 64-bit, 15.6 inch).

Traithlon jumping rope were used to skipping rope. Properties of the rope are automatic counter display, 306 rotatable handles, adjustable rope length, non-slip and sweat proof handles. Documentaries watched on TOSHIBA PC.

2.3. Exercise

Skip rope selected as the aerobic exercise by the experimenter. Neutral and evening types of participants exercised their own circadian routine. At the beginning of the exercise, between the most intense the set middle of skip rope and finishing the exercise the heart rate is measured. Also, after the 5 minutes resting period, measured the heart rate to see it has returned to normal or not. The skip rope exercise established 8 min warm-up, 10 min skip rope and 2 min cool down. Jump Rope Lite App is used to time management. Skip rope has 10 sets, 25 s rest and 35 s work in second and third weeks and in fourth week 12 sets, 25 s rest and 35 s work. The participants were allowed to drink water.

2.4. Procedure

Firstly, each participant fulfilled via online Google Forms Informed Consent, Demographic Form, Edinburgh Handedness Inventory, The Physical Activity Readiness Questionnaire, Sleeping Questionnaire, Morningness - Eveningness Questionnaire. After evaluation of Morningness - Eveningness Questionnaire scores, groups are divided into two group of participants due to circadian rhythm like neutral type and evening type both exercise and control group. According to circadian rhythm, each participant who comes the most efficient exercise time interval on a day and timeline determined for himself or herself once a week. The study was conducted in Izmir University of Economics psychology lab. First week, all information on the experiment protocol is provided and then participant fulfilled The Richards-Campbell

Sleep Questionnaire that is fulfilled each week before the experiment, after that does N-back paradigm. Paradigm starts with practice for all three conditions (0-back, 1back, 2-back), practice include feedback half and half. When practice is end successfully, three experiment stages begins. All procedures take 20 minutes for the first week. Second week, participant’s heart rate is measured and starts exercise in Izmir University of Economics backyard, whereas heart rate measurement done before watching video for control group. Heart rate measurements also taken from participant in the middle of the skipping rope and watching video. When exercise and video is finished in 20 minutes, heart rate is measured again and participants attends 5 minutes later N-back paradigm without practice. Third and fourth weeks are same procedures as second week. The last week is a week after last exercise and video, participants do N-back paradigm without exercise or watching video (Figure 7)

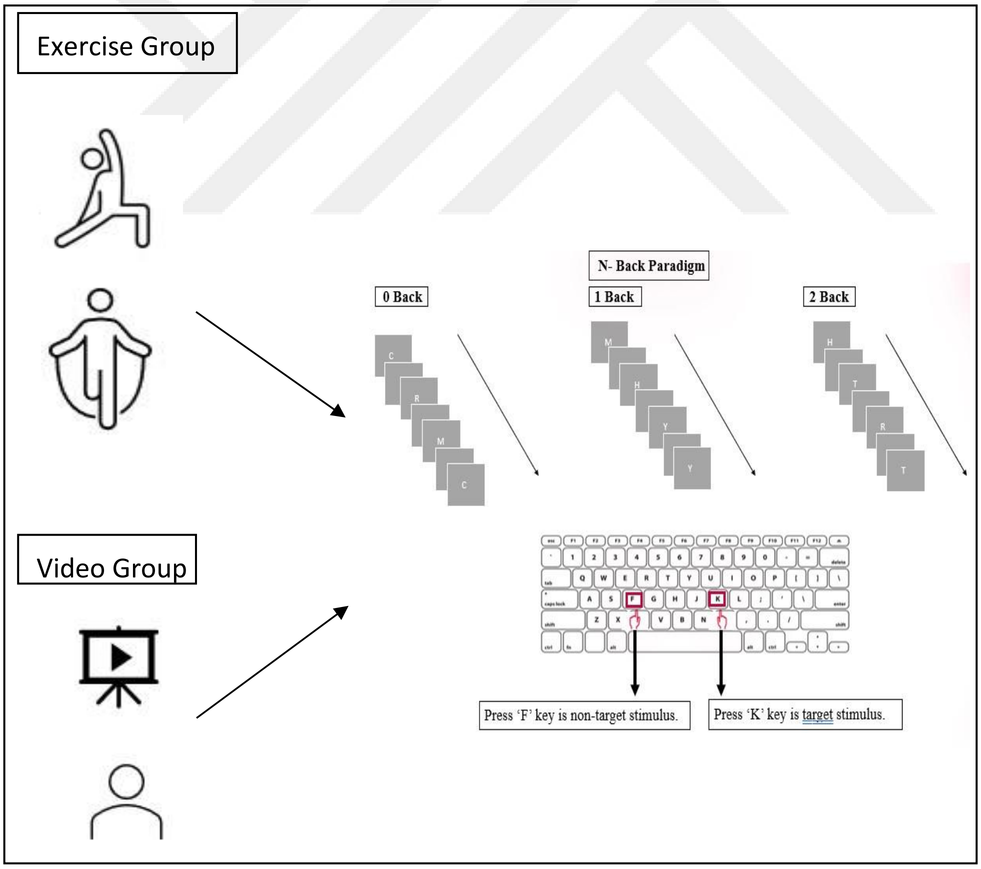

Figure 7. Illustrations of experimental design in exercise and video group.

CHAPTER 3: RESULTS

All analysis was performed with IBM SPSS 21 software to evaluate participants N-back performance during the process. The statistical analysis of the data acquires from N-back paradigm as described in the Method chapter are presented. The normality and homogeneity assumptions of the data acquired from N-back paradigm applied as baseline, first week, second week, third weeks and post measurement to the experiment group and video group. The thesis includes two Chronotype (*M*= 1.36, *SD*= .49) as Neutral (*M*= 1.52, *SD*= .51) and Evening Types (*M*= 1.54, *SD*= .52) and two Groups as Exercise (*M*= 1.35, *SD*= .49) and Video Group (*M*= 1.37, *SD*= .50) were between groups design and Time was within group design. A four-way mixed ANOVA were conducted to observe the effect of group (Exercise vs. Control/Video) and chronotype (Neutral and Evening Type) on accuracy rate and reaction time scores at N-back paradigm (0-back, 1-back and 2-back) depending on time (base, time 1, 2, 3 and post).

Table 3. Participants descriptive in both groups.

Chronotype	Neutral Type				Evening Type			
	Age	Height	Weight	BMI	Age	Height	Weight	BMI
Exercise Group	19.67	1.65	54.67	19.99	21.64	1.70	59.36	20.46
Video Group	23.13	1.68	58.63	20.69	21.55	1.72	65.55	22.16

Table 4. The changes in participant's heart rate during the exercise and video sessions.

Heart Rate	First Exercise / Video			Second Exercise / Video			Third Exercise / Video		
	Before	During	After	Before	During	After	Before	During	After
Exercise Group	89.29	135.76	94.65	90.71	152.35	95.71	91.41	165.53	95.59
Video Group	91.29	83.41	76.18	95.06	86.81	79.81	91.20	83.67	75.07

3.1. Target Accuracy Rate Results

Analyses conducted on the 36 participants (17 Exercise and 19 Control/Video Group) to investigate the relationship among exercise, chronotype and working memory. Accuracy rate of participants on target stimuli were analyzed with four-way mixed ANOVA. Analyses were conducted to observe the effect of group (Exercise vs. Control/Video) and chronotype (Neutral and Evening Type) on accuracy rate and reaction time scores at N-back paradigm (0-back, 1-back and 2-back) depending on time (base, time 1, 2, 3 and post). Mauchly's test indicated that the assumption of sphericity had been violated for the main effects of time, $\chi^2(9) = 26.20$, $p < .01$ and N-back $\chi^2(2) = 22.84$, $p < .001$ and also interaction effect of time and N-back interaction $\chi^2(35) = 83.91$, $p < .001$. Therefore, degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity ($\hat{\varepsilon} = .68$ for the main effect of time, $\hat{\varepsilon} = .62$ for the main effect of N-back and $\hat{\varepsilon} = .49$ for the interaction effect of Time and N-back). There was a significant main effect of time $F(2.72, 67.92) = 3.48$, $p < .05$ (Figure 8); N-back $F(1.24, 30.98) = 29.55$, $p < .001$ (Figure 9) and group $F(1, 25) = 4.47$, $p < .05$ (Figure 10) on participants' accuracy rate scores. There were no significant main effects of chronotype $F(1, 25) = 0.08$, $p = .78$. Participants' accuracy rate increased significantly with time. Base accuracy rate scores of participants were significantly lower than time 1 $F(1, 25) = 6.86$, $p < .05$, time 2 $F(1, 25) = 7.20$, $p < .05$ and post measurements $F(1, 25) = 5.84$, $p < .05$. Also, participants' accuracy rate score decreased with N-back task. 0-back had significantly higher accuracy rate scores than 1-back $F(1, 25) = 14.79$, $p < .01$ and 2-back $F(1, 25) = 37.22$, $p < .001$. Lastly, significant main effect of group showed significantly more accuracy rate scores on exercise group than control/video group $F(1, 25) = 4.72$, $p < .05$. The results showed that there was a significant interaction between the N-back and time $F(3.93, 98.18) = 10.00$, $p < .001$. This effect indicates that accuracy rate scores in N-back task were affected differently by the time. Specifically, accuracy rates of participants showed decreased patterns with time (from base to post measurement) at 0-back $F(1, 25) = 29.37$, $p < .001$ and 1-back $F(1, 25) = 20.76$, $p < .001$ compared to 2-back condition which showed increased patterns with time.

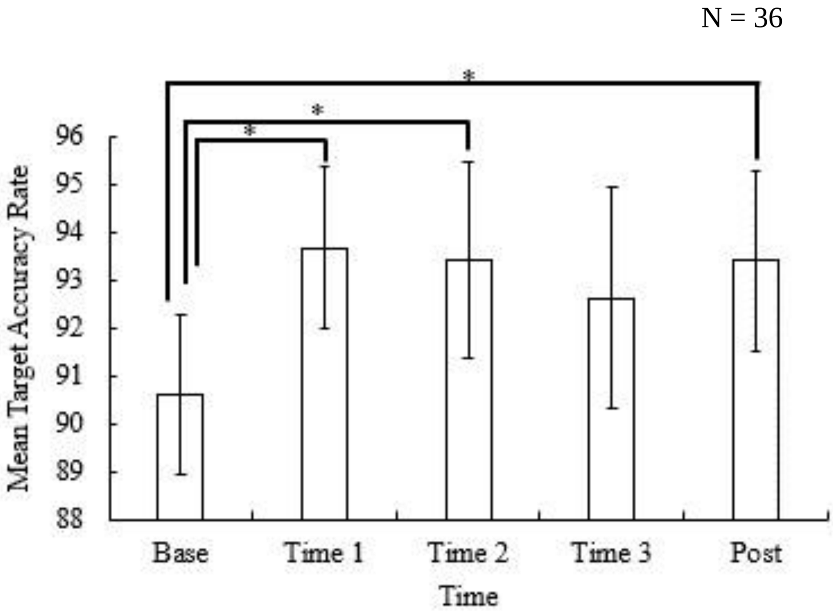

Figure 8. Mean Accuracy scores of target stimuli during time conditions (with adjusted 95% CIs) *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001.

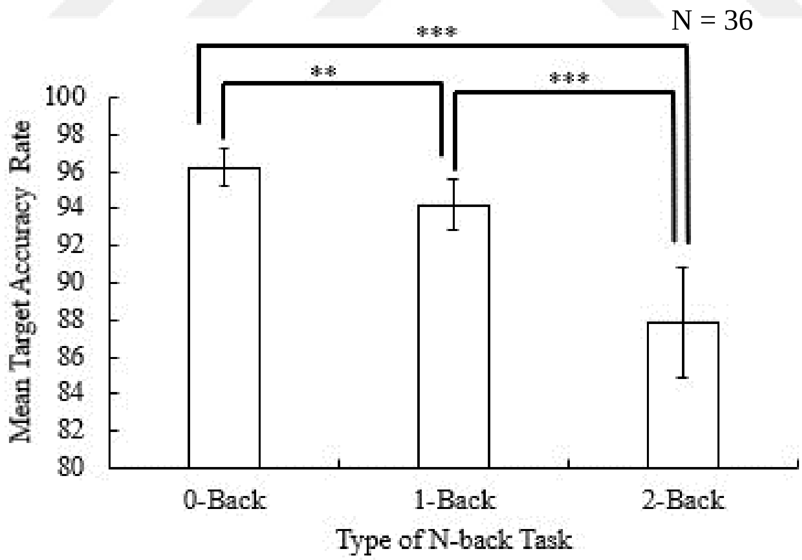

Figure 9. Mean Accuracy scores of target stimuli for different N-Back Conditions (with adjusted 95% CIs) *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001.

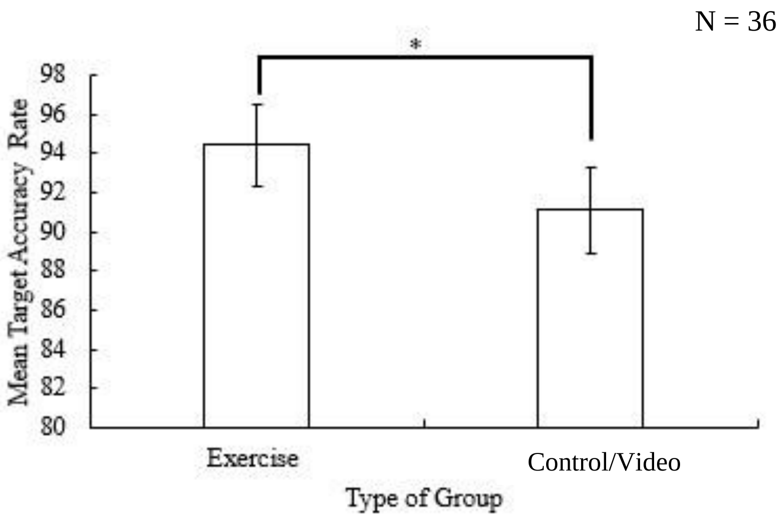

Figure 10. Mean Accuracy scores of target stimuli for groups (with adjusted 95% CIs) *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001.

When we examine this significant interaction between time and n-back in terms of the difference between groups, 0-back condition showed decreased pattern at both exercise and control/video group with time. However, the difference between time sessions was not significant for exercise group, it was significant only at the control/video group. After control/video group watched their first video; their accuracy scores at 0-back decreased significantly compared to third video watching (*MD* = 2.72, *SE* = 1.14, *p* < .05) and post measurements (*MD* = 2.64, *SE* = 1.22, *p* < .05) Figure 11. Participants' accuracy scores at 1-back task increased with time (from base to post measurement) at exercise group (*MD* = -2.73, *SE* = 1.30, *p* < .05); but, decreased at control/video group (*MD* = 3.32, *SE* = 1.38, *p* < .05) which showed significant difference at post measurement between (*M* = 97.18, *SE* = 1.31) exercise and (*M* = 91.08, *SE* = 1.38) control/video group $F(1, 25) = 10.29$, $p < .01$. The accuracy rate scores were also decreased significant from first video watching to post measurement (*MD* = 3.13, *SE* = 1.43, *p* < .05) Figure 12. Furthermore, accuracy scores of participants on the N-back 2 showed similar increasing pattern with time condition for both groups Figure 13. Accuracy scores increased dramatically for both control/video (*MD* = -9.15, *SE* = 3.42, *p* < .05) and exercise group (*MD* = -12.96, *SE* = 3.61, *p* < .01) after first exercise and video watching respectively. After this dramatic increase exercise group showed no significant difference with time; however, control/video group's accuracy scores decreased significantly from their second to third watching videos (*MD*= 4.13, *SE* = 1.85, *p* < .05).

N = 36

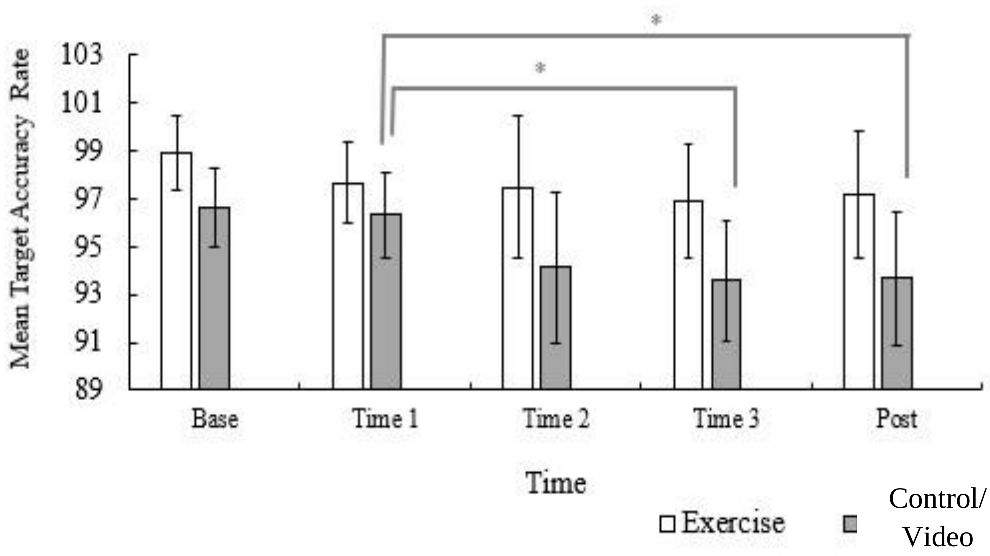

Figure 11. Mean Accuracy scores of target stimuli for 0-back condition during the time (with adjusted 95% CIs) by type of group. *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001

N = 36

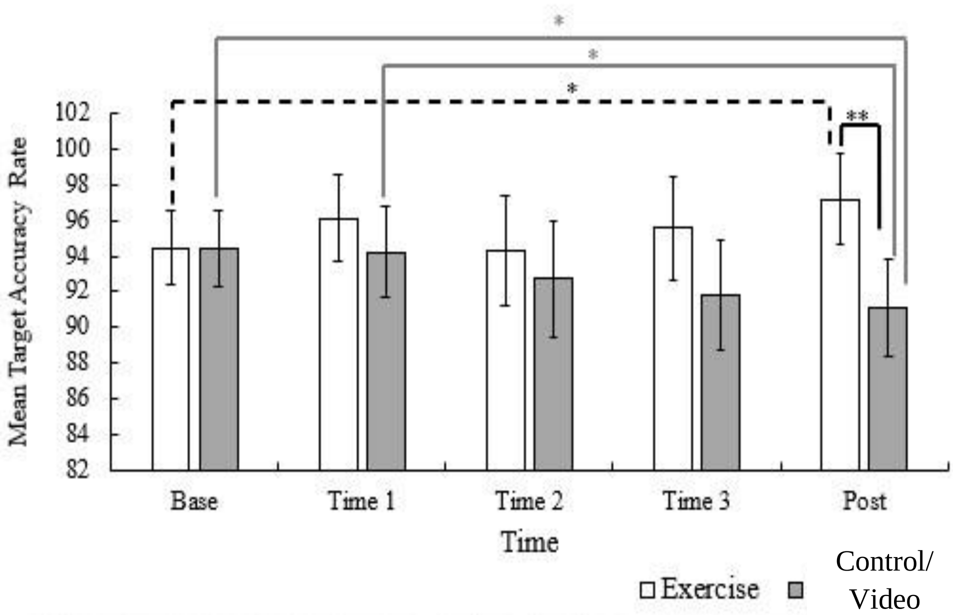

Figure 12. Mean Accuracy scores of target stimuli for 1-back condition during the time (with adjusted 95% CIs) by type of group. *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001

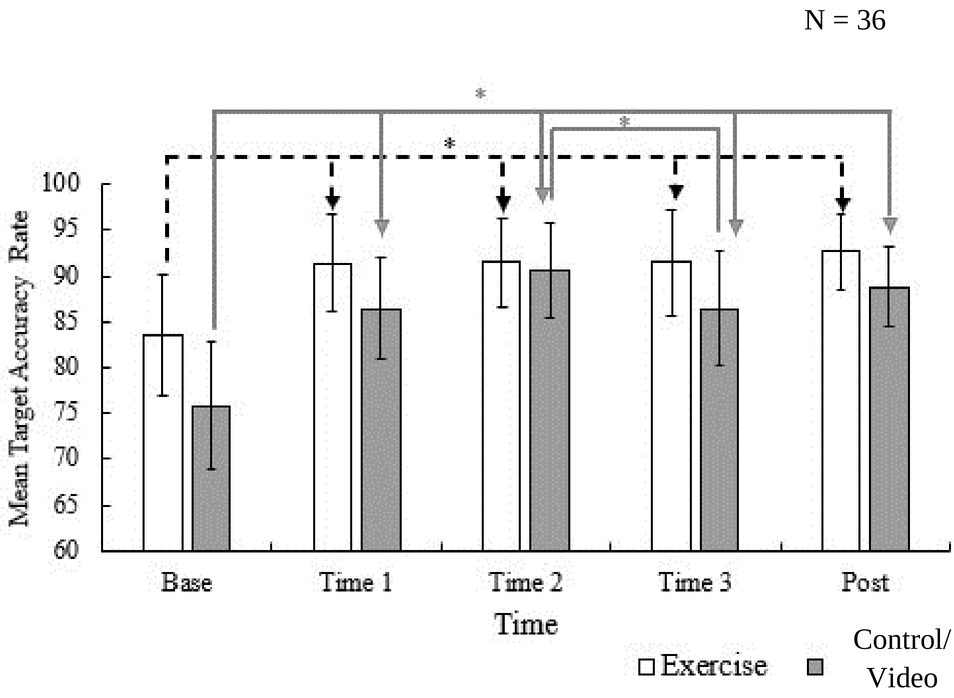

Figure 13. Mean Accuracy scores of target stimuli for 2-back condition during the time (with adjusted 95% CIs) by type of group. *s denotes significance at * $p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

3.2. Target Reaction Time Results

Analyses were conducted to observe the effect of group (Exercise vs. Control/video) and chronotype (Neutral and Evening Type) on reaction time scores at N-back paradigm (0back, 1-back and 2-back) depending on time (base, exercise 1, exercise 2, exercise 3 and post). Mauchly's test indicated that the assumption of sphericity had been violated for the main effects of N-back $\chi^2(2) = 42.56$, $p < .001$ and interaction effect of time and N-back $\chi^2(35) = 146.29$, $p < .001$. Therefore, degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity (εˆ= .56 for the main effect of N-back and εˆ= .43 for the interaction effect of Time and N-back). There was a significant main effect of time $F(4, 112) = 27.83$, $p < .001$; N-back $F(1.12, 31.23) = 35.33$, $p < .001$ and chronotype $F(1, 28) = 18.22$, $p < .001$ on participants' reaction time. There were no significant main effects of group $F(1, 28) = 0.13$, $p = .72$. Participants' reaction time decreased significantly with time. Base reaction time of participants were significantly higher than time 1 $F(1, 28) = 11.05$, $p < .01$, time 2 $F(1, 28) = 26.98$, $p < .001$, time 3 $F(1, 28) = 42.77$, $p < .001$ and post measurements $F(1, 28) = 54.57$, $p < .001$ (Figure 14). Also, participants' reaction times increased with N-back task. 0-back had significantly lower reaction time than 1-back $F(1, 28) = 14.98$, $p < .01$ and 2-back $F(1, 28) = 38.61$, $p < .001$. Also 1-back reaction time scores were significantly lower than 2-Back scores $F(1, 28) = 33.27$, $p < .001$ (Figure 15). Lastly, significant main effect of chronotype showed significantly more reaction time scores on evening type group than neutral type group *(MD* = 104.43, *SE* = 24.47, $p < .001$) (Figure 16). The results showed that there was a significant interaction between the N-back and time $F(3.43, 95.87) = 14.35$, $p < .001$. This effect indicates that reaction time scores in N-back task were affected differently by the time. Results of the contrast showed that 0back and 1-back conditions decreased with time in a similar pattern; however, 2-back condition decreased sharply when compared the 0-back from base to time 1 $F(1, 28) = 8.19$, $p < .01$, time 2 $F(1, 28) = 25.50$, $p < .001$, time 3 $F(1, 28) = 28.35$, $p < .001$ and post measurement $F(1, 28) = 25.94$, $p < .001$. Figure 17.

N = 36

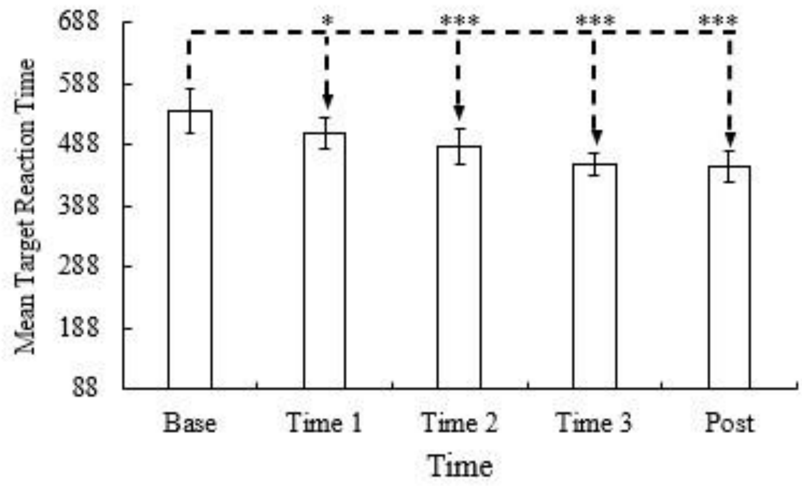

Figure 14. Mean reaction time of target stimuli during the time (with adjusted 95% CIs). *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001.

N = 36

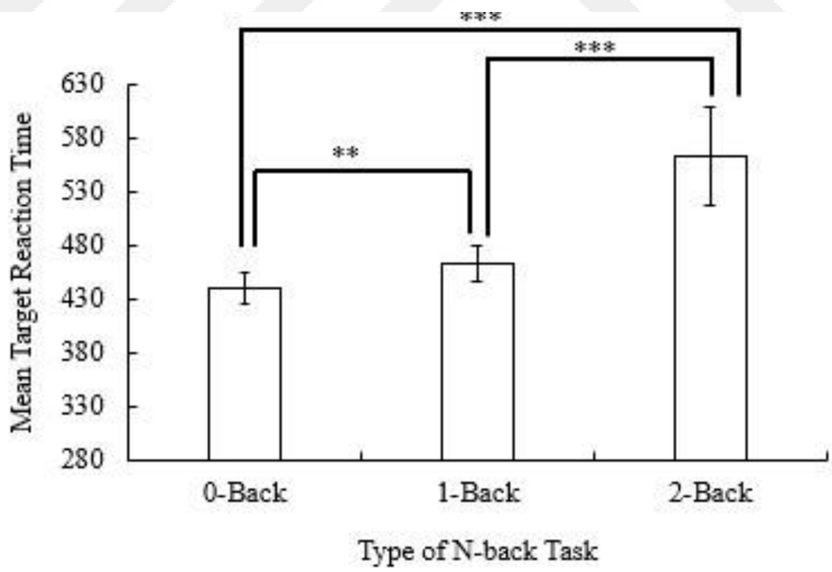

Figure 15. Mean reaction time of target stimuli at different N-back tasks (with adjusted 95% CIs). *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001.

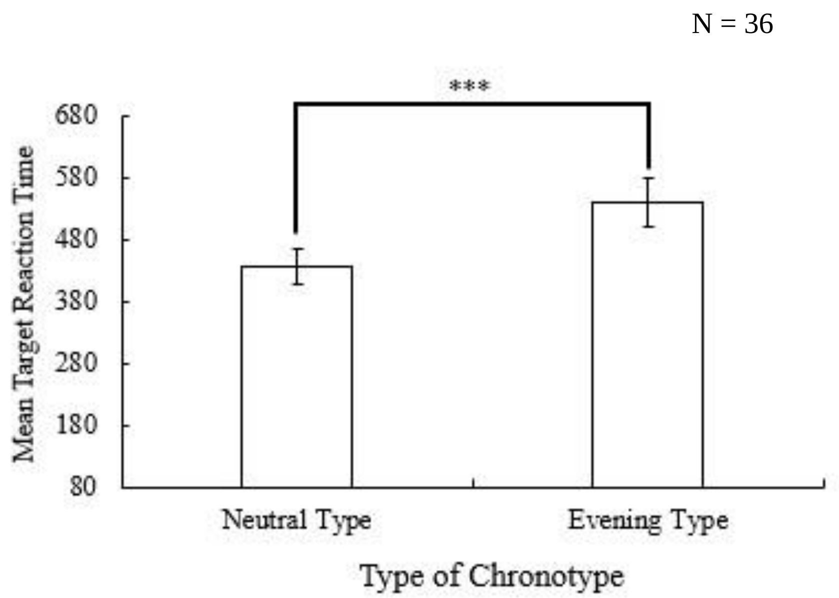

Figure 16. Mean reaction time of target stimuli at different chronotype (with adjusted 95% CIs). *s denotes significance at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

N = 36

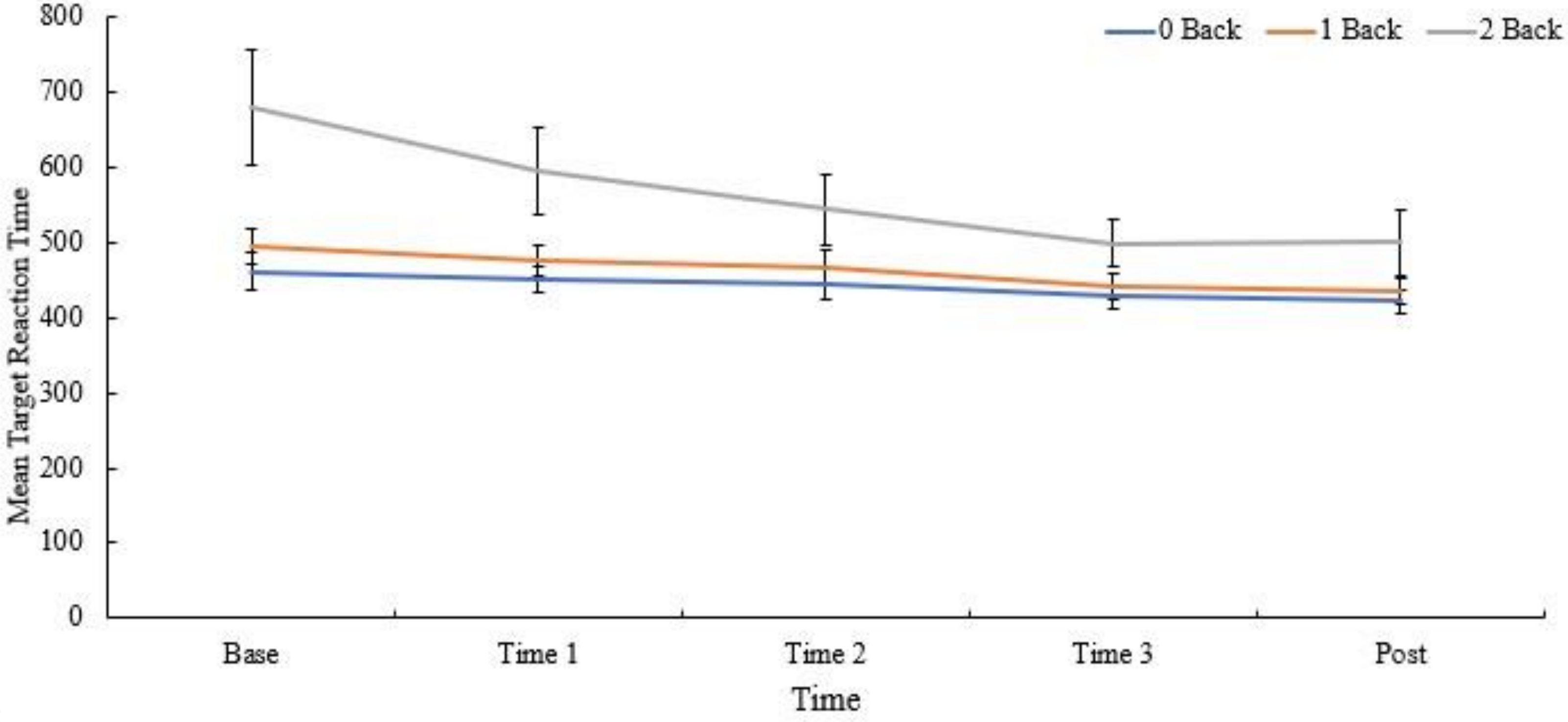

Figure 17. Mean reaction time of target stimuli for different N-back tasks during time (with adjusted 95% CIs) by type of chronotype. *s denotes significance at * $p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

3.3. Non-Target Accuracy Rate

Accuracy rate of participants on non-target stimuli were analyzed with four-way mixed ANOVA. Mauchly's test indicated that the assumption of sphericity had been violated for the main effects of time, $\chi^2(9) = 22.24$, $p < .001$, N-back $\chi^2(2) = 19.18$, $p < .001$ and interaction effect of Time and N-back interaction $\chi^2(35) = 76.41$, $p < .001$. Therefore, degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity ($\hat{\varepsilon} = .67$ for the main effect of time, $\hat{\varepsilon} = .65$ for the main effect of N-back and $\hat{\varepsilon} = .52$ for the interaction effect of Time and N-back). There was a significant main effect of time $F(2.69, 67.20) = 9.19$, $p < .001$; N-back $F(1.29, 32.25) = 26.71$, $p < .001$. However, there were no significant main effect of group $F(1, 25) = 2.12$, $p = .16$ and chronotype $F(1, 25) = 0.72$, $p = .40$ on participants' non-target accuracy rate scores.

Participants' accuracy rate increased significantly with time. Base accuracy rate scores of participants were significantly lower than time 1 $F(1, 25) = 8.64$, $p < .01$, time 2 $F(1, 25) = 19.35$, $p < .001$, time 3 $F(1, 25) = 13.27$, $p < .01$ and post measurements $F(1, 25) = 15.78$, $p < .01$ (Figure 16). Also, participants' accuracy rate score decreased with N-back task. 0-back had significantly higher accuracy rate scores than 1-back $F(1, 25) = 18.60$, $p < .001$ and 2-back $F(1, 25) = 44.63$, $p < .001$ (Figure 17). The results showed that there was a significant interaction between the N-back and time $F(4.19, 104.85) = 7.94$, $p < .001$. This effect indicates that accuracy rate scores on non-target stimuli in N-back task were affected differently by the time. Specifically, accuracy rates of participants showed no significant difference on 0-back and 1-back conditions with time. However, 2-back condition showed significant increase with time from base to time 1 (MD = -3.77, SE = 1.07, p < .01); time 2 *(MD = -4.89, SE = 1.06, p < .001)*; time 3 *(MD = -4.22, SE = 1.12, p < .01)* and post measurements *(MD = -5.03, SE = 1.09, p* < .001) (Figure 18)

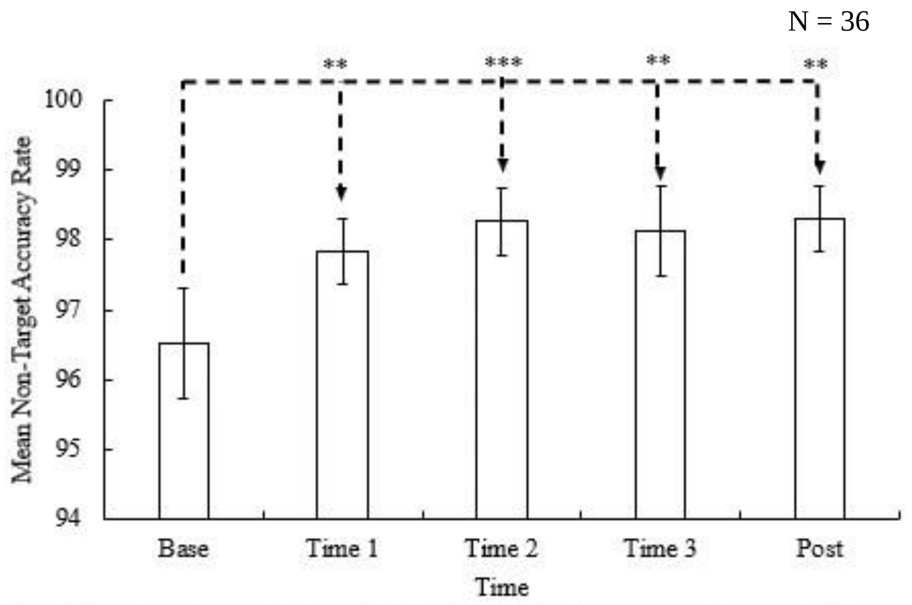

Figure 18. Mean Accuracy scores of non-target stimuli during time conditions (with adjusted 95% CIs) *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001**p < 0.01, ***p < 0.001.

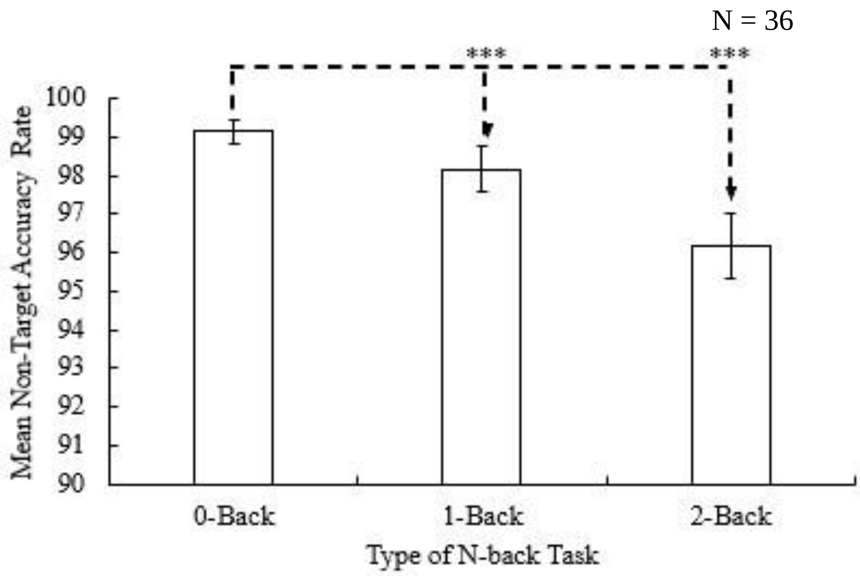

Figure 19. Mean Accuracy scores of Non-Target stimuli for different N-Back Conditions (with adjusted 95% CIs) *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001.

N = 36

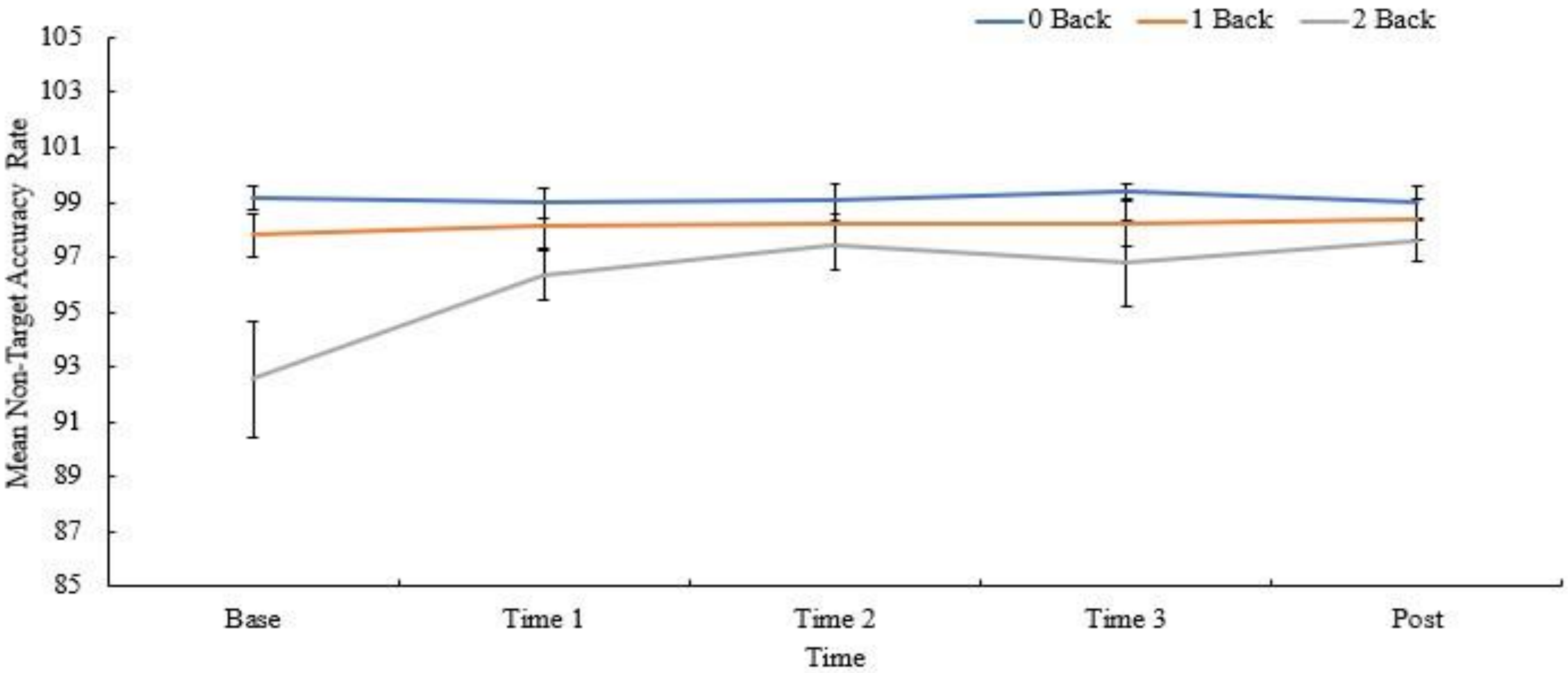

Figure 20. Mean Accuracy scores of Non-Target stimuli for different N-back tasks during time (with adjusted 95% CIs) by type of group. *s denotes significance at * $p < 0.05$, **$p < 0.01$, ***$p < 0.001$

3.4. Non-Target Reaction Time Results

Reaction time of participants on non-target stimuli were analyzed with four-way mixed ANOVA. Mauchly's test indicated that the assumption of sphericity had been violated for the main effects of time, $\chi^2(9) = 54.86$, $p < .001$, N-back $\chi^2(2) = 38.40$, $p < .001$ and interaction effect of Time and N-back $\chi^2(35) = 179.40$, $p < .001$. Therefore, degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity ($\hat{\varepsilon} = .50$ for the main effect of time, $\hat{\varepsilon} = .58$ for the main effect of N-back and $\hat{\varepsilon} = .35$ for the interaction effect of Time and N-back). There was a significant main effect of time $F(1.99, 61.59) = 56.86$, $p < .001$; N-back $F(1.16, 36.01) = 49.65$, $p < .001$ and chronotype $F(1, 31) = 9.32$, $p < .01$ on participants' reaction time. There were no significant main effects of group $F(1, 31) = 1.31$, $p = .26$. Participants' reaction time decreased significantly with time. Base reaction time of participants were significantly higher than time 1 $F(1, 31) = 26.31$, $p < .001$, time 2 $F(1, 31) = 59.35$, $p < .001$, time 3 $F(1, 31) = 80.27$, $p < .001$ and post measurements $F(1, 31) = 76.07$, $p < .001$ (Figure 21). Also, participants' reaction times increased with N-back task. 0back had significantly lower reaction time than 1-back $F(1, 31) = 35.87$, $p < .001$ and 2-back $F(1, 31) = 57.53$, $p < .001$. Also 1-back reaction time scores were significantly lower than 2-Back scores $F(1, 31) = 41.24$, $p < .001$ (Figure 22). Lastly, significant main effect of chronotype showed significantly more reaction time scores on evening type group than neutral type group *(MD = 87.29, SE = 28.59,* $p < .001$*)* (Figure 23). The results showed that there was a significant interaction between the N-back and time $F(2.76, 85.44) = 15.71$, $p < .001$. This effect indicates that reaction time scores in N-back task were affected differently by the time. Results of the contrast showed that 0-back and 1-back conditions decreased with time in a similar pattern; however, 2back condition decreased sharply when compared the 0-back from base to time 1 $F(1, 31) = 10.83$, $p < .01$, time 2 $F(1, 31) = 25.40$, $p < .001$, time 3 $F(1, 231) = 32.14$, $p < .001$ and post measurement $F(1, 31) = 30.20$, $p < .001$. Figure 24.

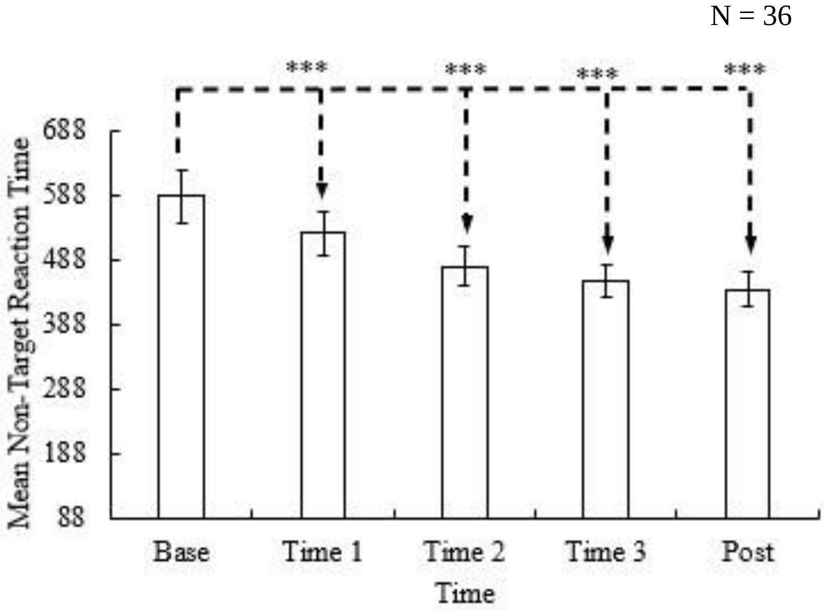

Figure 21. Mean reaction time of Non-Target stimuli during time (with adjusted 95% CIs). *s denotes significance at * p < 0.05, **p < 0.01, ***p < 0.001.

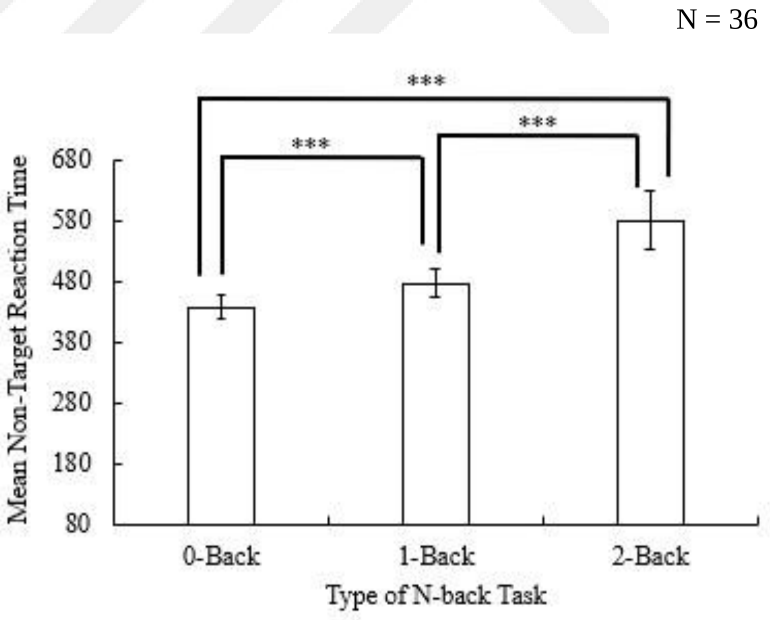

Figure 22. Mean reaction time of Non-Target stimuli during time (with adjusted 95% CIs). *s denote significance at * p < 0.05, **p < 0.01, ***p < 0.001.

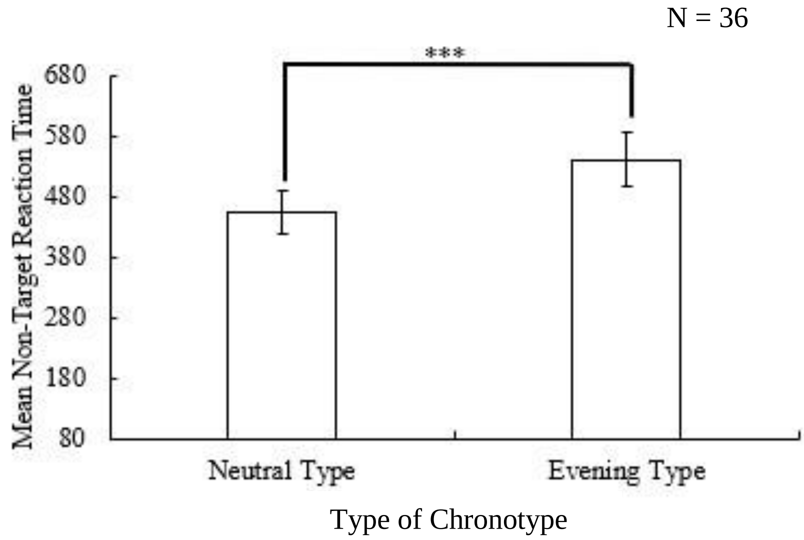

Figure 23. Mean reaction time of non-target stimuli for Chronotype (with adjusted 95% CIs) *s denote significance at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

CHAPTER 4: DISCUSSION

As for main research questions and investigation part, the thesis aimed at providing explanations for following results. The major purpose of this thesis was to assess the influence of exercise and circadian rhythm on WM performance in young adults. Additionally, this thesis aimed at investigating there could be any differences between chronotypes effects of WM performance with particular focus on interpreting the young adults. WM performance evaluated in between skipping rope with one day a week for 3 weeks as well as watching documentaries one day a week for 3 weeks at participant's optimal time, also base and post-measurement.

All N-back conditions were evaluated independently in order to more accurately detailed about WM performance. N-back condition includes 0, 1, 2- back condition for each three trial and all sequence per week for each participant. This would be useful for focusing on average improvements in all N-back conditions. The results show that participants' accuracy rates means that from 0-back to 2-back condition difficulties and WM load is increased. Both exercise and video group had nearly similar accuracy rates mean responses in each condition for the baseline. It means that applied randomization between groups was successful in this thesis design.

In 0-back condition, exercise group and video group decreased target accuracy, but exercise group had not significantly differenced during the 5 weeks compared to video group. 0-back conditions associated with attention and baseline process in the N-back paradigm. Therefore. Exercise groups stayed stable about the attention, in contrast the video group. When compared into target reaction time in 0-back condition. Exercise groups is sharply and significantly decreased, although both groups had decreased pattern.

In 1- back condition that provides working memory load moderately. The condition holds and update working memory process attentional (Cohen et al., 2020). Both groups have nearly same target accuracy rate for the baseline, but timely exercise group has greater target accuracy rate, however video group is decreased slightly. The less demanding 1-back condition target reaction time again exercise group had highly significant decreasing than the video group.

In 2- back condition that is higher WM load condition. Exercise group had higher target accuracy rate than video group and they were also steady decreased for target reaction time. This condition is more need to comparison to stimuli and enhance executive function of WM, because targets higher level of cognitive process. It includes updating, inhibition and attentional control/video (Cohen et al., 2020).

Moderate intensity of exercise might be providing better WM performance. (Loprinzi, 2018). As showed in results, exercise group had better accuracy rate and rapidly reaction time. The time of the exercise session has a relationship in the exercise and memory that influence to aspect of the memory task (Roig et al., 2016). In this thesis exercise condition had 3 weeks and 20 minutes per week. Moderate intensity of exercise linked with improved executive function. Results shows that, regular exercise might be associated with better performance on the N-back such as attention, updating and manipulation of information. Moreover, it should be noted that exercise duration has some positive effect about exercise on WM. For instance, Martins et al. (2013) and Komiyama et al. (2017) found that working memory performance was improved in Sternberg task and delayed response task during moderate-intensity exercise in young adults. In this thesis support this contribution with N-back task. Skipping rope is newly studied and had a positive effect on the WM performance. Skipping rope is form of aerobic exercise that can also improve cardiovascular fitness. During the exercise session, it increased blood flow and delivery of oxygen to supporting WM optimal function. It needs more attention, coordination and timing. Participants must sustain focus, maintain rhythm and coordinate their movement. This process can be playing effective role on N-back paradigm. The thesis opened new looks this integration. Because of that skipping rope exercise process needs more investigation in different ages group and need to learn what sis the consequences in brain connection about WM areas.

The perspective of chronotype, neutral types had lower reaction time and higher accuracy rate compared to evening type in both groups. All chronotypes performed in their optimal time. Exercise and circadian rhythm have bidirectional effect. The effect of exercise on working memory performance is also influence of circadian rhythm on levels of cortical arousal (Carrier and Monk, 2000). Both exercise and circadian rhythm affect neurotransmitter and neurohormone levels, they change during difference of them. Most important thing is regular exercise increase growth hormone concentration, increase neurogenesis in the hippocampus, in memory of animals improves (van Praag et al., 1999), also bring about improvements in executive function of human (Kramer et al., 1999). Regular exercise also reinforces the human body's internal and molecular clock. An earlier review shows that memory performance peaks in a different time of the day, also optimal performance depends on nature of the tasks. They indicate that between chronotype and N-back paradigm relations is complex and difference of types is not yet understood. Moreover, this thesis shows the effect of exercise with chronotype in the N-back task firstly. Some literature review show that, an athlete might be performed on exercise at different times of the day. The performance of the athletes should be training and preparing due to the competition. Research revealed that, between the circadian rhythm and exercise is interacted with each other in a positive way. Moreover, during the moderate intensity exercise, there is an increase heart rate and increasing the blood flow might be promoting neuroplasticity for the executive function. The thesis of post measurement means the chronic measurement; it leads to better performance on the WM tasks. In chronotype also can affected by sleep quality, sleep duration and body temperature on executive function. Moreover, the chronotype and N-back task performance is still doubtful. According to this thesis results, evening and neutral types have some differences in reaction time and accuracy rate but where is come from the difference of these part, it should be more research investigation. Moreover, including the neurobiological and neural oscillations has been investigated in neuroimaging techniques. In WM, neural activity in fronto-parietal network will be investigated. Dorsolateral and dorsomedial frontal network areas connection might be enlightened to the thesis chronotype results clearly.

Age- related differences are influenced in all main effect like exercise chronotypes and WM performance. Moreover, the frontal brain changes with age, some neuroimaging technique shows that, there was an increasing activity in the left inferior frontal and orbitofrontal gyrus from child and young adult (Tamm et al., 2002). These areas located in frontal cortex and had important role in executive function. Developmental changes might be effect of exercise on inhibitory control and WM from pre-adolescence to young adult. If moderate- intensity exercise has enough time to change WM performance in a positive way, it might be potential to induce plasticity effect in specific brain areas.

A follow-up study that will be again an exercise training intervention taking into account in chronotypes on WM performance wide range of different ages. Other study should be noted that same procedure in longitudinal study. Furthermore, this thesis procedure should be investigated with neuroimaging technique. It will be good opportunity to follow the connection between related WM and exercise brain regions. Also, exercise effect lots of health benefits and this mechanism still explored. The latest reviews provide that acute and chronic exercise are positive effect for inhibition control and executive function. The mechanism of the exercise is still unclear. However, this thesis and upcoming research contribute new feature of this are. Considering the circadian mechanism in time of the day principle, improves the outcomes of exercise for WM. Also, EEG might be the more effective to seeing connection circadian rhythm oscillation and effect of exercise on WM performance. Although the neural correlates of n-back task have been largely studied with various neuroimaging methods (Owen et al., 2005), there might be some compared to these results.

4.1. Limitation

Randomization was adequately correct, but the sample size in both groups might be expanded. Exercise training had not enough time. In the study, finding participants was difficult because of the online education that was due to Kahramanmaraş' earthquake. Other limitation is time of exercise must be shorter than planned. All limitation is considered and they are giving crucial feedback to replicate and improve path for new studies. A larger sample, longer exercise training time might compare to these results. Skipping rope exercise was great challenge and some exercise training sessions add some new techniques, or its structure can be sustainable.

4.2. Conclusion

The main role of this thesis is to understand exercise and circadian rhythm provide an elaborated view of processing and their impacts on WM performances. Therefore, WM performance that is limited, related with various cognitive process is directly correlated with WM. When limitation into account, process and the result provide us new step for the future. A multidisciplinary approach was used in the design of this thesis, bring together explanation from circadian rhythm (biology), exercise (sport), WM (psychology).

The main aim of the thesis was to investigate transfer effects of n-back WM training at various N-back condition and interpreting which is a highly demanding part of the WM performance. With behavioral data, this thesis incorporated a cross-sectional study approach in order to establish a systematically analysis of acute and chronic exercise effects with chronotypes of the participant on WM performance. The present study results demonstrate a specific mechanism through exercise benefits on executive function of WM performance. It provides testable predictions for future studies utilizing acute and chronic exercise sessions. In this endeavor may benefits from an acute exercise since it provides a low cost and rapid evaluation of variety of exercise manipulations. The benefit of chronic exercise provides long-term cost and permanent manipulation. All participants were encouraging to moderate-intensity exercise, some of them had already stared as soon as the study was end.

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APPENDICES

APPENDIX A- Informed Consent (1)

BİLGİLENDİRİLMİŞ ONAM FORMU (1)

Sayın Katılımcı,

Bu araştırma, İzmir Ekonomi Üniversitesi Deneysel Psikoloji Yüksek Lisansı tez çalışması kapsamında Prof. Dr. Canan BAŞAR EROĞLU danışmanlığında, yüksek lisans öğrencisi Kübra ALTUNTAŞ tarafından hazırlanmıştır.

Araştırmanın amacı, genç yetişkinlerde, video izlemenin ve sirkadiyen ritmin (sabahçıl-akşamcıl) çalışma belleği üzerindeki etkisi incelemektir.

Anket çalışmamız yaklaşık 15 dakika sürecektir. Bu araştırmaya katılmak tamamen gönüllülük esasına dayanmaktadır. Araştırmaya katılmama veya katıldıktan sonra istediğiniz herhangi bir anda araştırmadan ayrılma hakkına sahipsinizdir. Araştırmanın neden ve nasıl yürütüleceğine dair herhangi bir sorunuz varsa lütfen araştırmacıya sormaktan çekinmeyiniz.

Araştırmayı yürütürken sizden hiçbir kimlik bilgisi talep edilmeyecektir. Cevaplarınız gizli tutulacak, yalnızca araştırma görevlileri tarafından değerlendirilecektir. Bu anketten elde edilen sonuçlar, yalnızca bilimsel amaçlar doğrultusunda kullanılacaktır. Ankette bulunan sorulara vereceğiniz cevapların doğruluğu, araştırmanın niteliği açısından oldukça önemlidir. Bu nedenle ankette bulunan tüm soruları samimiyetle cevaplamanızı rica ederiz.

İş birliğiniz için teşekkür ederiz.

- ☐ Ankete katılmak istiyorum.
- ☐ Ankete katılmak istemiyorum

Katılımcının;

Adı Soyadı

Tarih:

İmza:

İletişim Bilgileri

Kübra Altuntaş: kubraaaltuntas@hotmail.com

APPENDIX A.1- Informed Consent

BİLGİLENDİRİLMİŞ ONAM FORMU (2)

Sayın Katılımcı,

Bu araştırma, İzmir Ekonomi Üniversitesi Deneysel Psikoloji Yüksek Lisansı tez çalışması kapsamında Prof. Dr. Canan BAŞAR EROĞLU danışmanlığında, yüksek lisans öğrencisi Kübra ALTUNTAŞ tarafından hazırlanmıştır.

Araştırmanın amacı, genç yetişkinlerde, video izlemenin ve sirkadiyen ritmin (sabahçıl-akşamcıl) çalışma belleği üzerindeki etkisi incelemektir

Anket çalışmamız yaklaşık 15 dakika sürecektir. Bu araştırmaya katılmak tamamen gönüllülük esasına dayanmaktadır. Araştırmaya katılmama veya katıldıktan sonra istediğiniz herhangi bir anda araştırmadan ayrılma hakkına sahipsinizdir. Araştırmanın neden ve nasıl yürütüleceğine dair herhangi bir sorunuz varsa lütfen araştırmacıya sormaktan çekinmeyiniz.

Araştırmayı yürütürken sizden hiçbir kimlik bilgisi talep edilmeyecektir. Cevaplarınız gizli tutulacak, yalnızca araştırma görevlileri tarafından değerlendirilecektir. Bu anketten elde edilen sonuçlar, yalnızca bilimsel amaçlar doğrultusunda kullanılacaktır. Ankette bulunan sorulara vereceğiniz cevapların doğruluğu, araştırmanın niteliği açısından oldukça önemlidir. Bu nedenle ankette bulunan tüm soruları samimiyetle cevaplamanızı rica ederiz.

İş birliğiniz için teşekkür ederiz.

☐ Ankete katılmak istiyorum.

☐ Ankete katılmak istemiyorum

Katılımcının;

Adı Soyadı

Tarih:

İmza:

İletişim Bilgileri

Kübra Altuntaş: kubraaltuntas@hotmail.com

APPENDIX B- Demografic Form

GENEL BİLGİLER

1) **Cinsiyetiniz: _______**

2) **Yaşınız: _______**

3) **Eğitim Durumunuz (Veya Devam Etmekte Olduğunuz):**

 İlkokul Ortaokul Lise Ön Lisans Lisans
 Lisansüstü

4) **Boy: _____ cm Vücut ağırlığı: _____Kg BKI (kg/m²) : _____**

5) **Tanı koyulmuş herhangi bir fiziksel (şeker, tansiyon, .. vb) ya da psikiyatrik (anksiyete, dikkat eksikliği, .. vb) rahatsızlığınız var mı?**

 Evet Hayır
Evet ise nedir: ________________________________

6) **Düzenli kullandığınız herhangi bir ilaç var mı?**

 Evet Hayır
Evet ise nedir: ________________________________

7) **Sigara kullanıyor musunuz?**

 Evet Bazen Hayır

8) **Alkol kullanıyor musunuz?**

 Evet Bazen Hayır

9) **Düzenli olarak fiziksel aktivite yapıyor musunuz?**

 Evet Bazen Hayır

Evet ise türü nedir; ________________________________

APPENDIX C- Edinburg Handedness Inventory

EDİNBURGH EL TERCİH ANKETİ

Aşağıdaki anketi cevaplarken günlük yapılan her bir aktivitenin cevabı için oluşturulan kutulara '✓' işareti yerleştiriniz.

Aktivite	Sol El		Sağ El		Her İki El Kullanımı	Toplam
	Daima	Genellikle	Daima	Genellikle		
1) Yazı yazarken kalemi hangi elinizle tutarsınız?						
2) Resim çizerken fırça veya kalemi hangi elinizle tutarsınız?						
3) Taşı atarken, fırlatırken hangi elinizle tutarsınız?						
4) Kumaşı keserken hangi elinizle makası tutarsınız?						
5) Diş fırçalarken fırçayı hangi elinizle tutarsınız?						
6) Ekmek keserken hangi elinizle bıçağı tutarsınız?						
7) Çorba içerken hangi elinizle kaşığı tutarsınız?						
8) Süpürge kullanırken en üstte hangi elinizi kullanırsınız?						

9) Kibrit çakarken kibriti hangi elinizle tutarsınız?						
10) Kavanoz açarken hangi elinizle kapağı tutarsınız?						
Toplam						

APPENDIX D- The Physical Activity Readiness Questionnaire (PAR-Q)

FİZİKSEL AKTİVİTEYE UYGUNLUK ANKETİ

Aşağıdaki soruları dikkatlice okuyunuz ve her birine size en yakın gelen cevabı veriniz.

Lütfen EVET veya HAYIR şıkkının yanındaki kutuyu işaretleyiniz.

1) Doktorunuz tarafından, kalp hastalığınız olduğunu ve sadece bir hekim tarafından tavsiye edilen fiziksel aktiviteleri yapmanız gerektiğini hiç söyledi mi?	☐ Evet ☐ Hayır
2) Fiziksel aktivite yaparken göğsünüzde ağrı hissediyor musunuz?	☐ Evet ☐ Hayır
3) Geçtiğimiz aylar içinde fiziksel aktivitede bulunmadığınız sırada göğsünüzde ağrı hissettiniz mi?	☐ Evet ☐ Hayır
4) Baş dönmesi nedeniyle denge kaybı yaşıyor musunuz veya bilincinizi kaybettiğiniz oluyor mu?	☐ Evet ☐ Hayır
5) Fiziksel aktivite düzeyinde değişiklik yaptığınızda kötüleşebilecek bir kemik veya eklem rahatsızlığınız (örn. sırt, diz veya kalçada) var mı?	☐ Evet ☐ Hayır
6) Tansiyon veya kalp hastalığı nedeniyle doktorunuz tarafından verilen reçeteli bir ilaç (örn. tansiyon düşürücü, idrar söktürücü ilaçlar gibi) kullanıyor musunuz?	☐ Evet ☐ Hayır
7) Fiziksel aktivite yapmamanızı gerektiren başka herhangi bir neden var mı?	☐ Evet ☐ Hayır

APPENDIX E- Sleeping Questionnaire

UYKU FORMU

Aşağıdaki soruları günlük ve haftalık rutinlerinizi göz önünde bulundurarak cevaplayınız.

1) Günde ortalama kaç saat uyursunuz?

....

2) Genellikle saat kaçta uyursunuz?

....

3) Genellikle saat kaçta uyanırsınız?

....

4) Dün gece saat kaçta uyudunuz?

....

5) Bu sabah saat kaçta uyandınız?

....

6) Şu anda kendinizi ne kadar uykusuz hissediyorsunuz? Sayıyı daire içine alınız.

1	2	3	4	5	6	7
Hiç uykusuz değilim						Çok uykusuzum

7)

a) Hafta içi/ hafta sonu uyku saatleriniz arasında fark oluyor mu?

☐ Evet ☐ Hayır

Yanıt EVET ise; ....

b) Hafta sonu hafta içine göre kaç saat daha geç veya erken uyanırsınız?

☐ Geç ☐ Erken

c) Hafta sonu hafta içine göre kaç saat daha geç veya erken uyursunuz? ☐ Geç ☐ Erken

8)

a) Yakın zamanda uyku düzeninizin dışına çıktınız mı?

☐ Evet ☐ Hayır

Yanıt EVET ise;

b) Ne zaman ve ne sebeple? ....

9)

a) Gün içinde kafein aldınız mı?

 Evet Hayır

Yanıt EVET ise;

b) Kafein içeren hangi içeceği içtiniz, ne tür/büyüklükte bardakta ve kaç bardak?

....

10)

a) Bazı kişiler kafein içeren içecekler/maddeler aldıklarında kafein hassasiyeti yaşayarak uyumakta güçlük çekmek, mide ağrısı, irritasyon gibi etkiler yaşarlar. Siz kafeine hassas biri misiniz?

 Evet Hayır

Yanıt EVET ise;

b) Kafeine ne kadar hassas olduğunuzu aşağıdaki ölçekte sayıyı daire içine alarak derecelendiriniz.

1	2	3	4	5	6	7
Kafeine hiç hassas değilim						Kafeine çok hassasım

APPENDIX F- Morningness - Eveningness Questionnaire (MEQ)

SABAHÇIL – AKŞAMCIL ÖLÇEĞİ

İnsanlar yaşam biçimleri, uyku-uyanıklık düzenleri ve gösterdikleri performansların zamanı bakımından "sabah tipi" ve "akşam tipi" şeklinde sınıflandırılabilirler. Aşağıda bununla ilgili sorular bulunmaktadır. Lütfen her bir soruyu cevaplandırmadan önce dikkatli bir şekilde okuyun. Tüm soruları cevaplandırın. Her bir soru için cevabınız diğerlerinden bağımsız olmalıdır, geri dönmeyin ve cevaplarınızı kontrol etmeyin. Her bir soru için bir tek cevap seçin. Size doğru gelen seçeneği uygun sayıyı dikkate alarak işaretleyin.

1) Eğer gündüz planlarınızı başkalarından bağımsız olarak tek başınıza yapabilmiş olsaydınız saat kaç civarında yataktan kalkmak sizin için en uygunu olurdu?

- Sabah 05:00 - Sabah 06:30 ( ) 5
- Sabah 06:30 - Sabah 07:45 ( ) 4
- Sabah 07:45 - Sabah 09:45 ( ) 3
- Sabah 09:45 - Sabah 11:00 ( ) 2
- Sabah 11:00 - Öğle 12:00 ( ) 1
- Öğle 12:00 - Sabah 05:00 ( ) 0

2) Eğer akşam planlarınızı başkalarından bağımsız olarak tek başınıza yapabilmiş olsaydınız saat kaç civarında yatmak sizin için en uygunu olurdu?

- Akşam 20:00 - Gece 21:00 ( ) 5
- Gece 21:00 - Gece 22:00 ( ) 4
- Gece 22:00 - Gece yarısından sonra 23:00 ( ) 3
- Gece yarısından sonra 23:00 - Sabah 02:00 ( ) 2
- Sabah 02:00 - Sabah 03:00 ( ) 1
- Sabah 03:00 - Sabah 08:00 ( ) 0

3) Sabahları belli bir saatte kalkmak zorunda olduğunuzda saat kurup zil sesiyle uyanmaya ne derecede kendinizi bağımlı hissedersiniz?

- Hiç bağımlı hissetmem ( ) 4
- Çok az bağımlı hissederim ( ) 3
- Oldukça bağımlı hissederim ( ) 2
- Çok bağımlı hissederim ( ) 1

4) Çevresel şartlar tam olarak uygun olsa sabahları yataktan kalkmak size ne denli kolay gelir?

- Asla kolay gelmez ( ) 1
- Çok kolay gelmez ( ) 2

- Oldukça kolay gelir ( ) 3
- Çok kolay gelir ( ) 4

5) Sabahları kalktıktan sonraki ilk bir saat içinde kendinizi ne denli canlı ve uyanık hissedersiniz?

- Asla canlı hissetmem ( ) 1
- Hafif canlı hissederim ( ) 2
- Oldukça canlı hissederim ( ) 3
- Çok canlı hissederim ( ) 4

6) Sabahları kalktıktan sonraki ilk bir saat süresince iştahınız nasıldır?

- Çok kötü ( ) 1
- Oldukça kötü ( ) 2
- Oldukça iyi ( ) 3
- Çok iyi ( ) 4

7) Sabahları kalktıktan sonraki ilk bir saat içinde kendinizi ne denli yorgun hissedersiniz?

- Çok yorgun ( ) 1
- Oldukça yorgun ( ) 2
- Oldukça dinlenmiş ( ) 3
- Çok dinlenmiş ( ) 4

8) Ertesi güne ait bir randevu ya da işiniz olmadığında her zamanki yatma vaktinize göre erken ya da geç mi yatarsınız?

- Asla geç yatmam ( ) 4
- 1 saatten daha az geç yatarım ( ) 3
- 1-2 saat daha geç yatarım ( ) 2
- 2 saatten daha fazla gecikirim ( ) 1

9) Biraz fiziksel egzersiz yapmaya karar verdiniz. Bir arkadaşınızın da bunu haftada iki kez ve birer saat yapmanızın uygun olduğunu belirterek bunun için en iyi zamanın sabah 07:00-08:00 arası olduğunu söyledi. Bu saatlerde en iyi performansını gösterebilir misin?

- İyi bir şekilde gerçekleşeceğini düşünürüm ( ) 4
- Orta derecede başarılı olurum ( ) 3
- Güç olacaktır ( ) 2
- Çok güç olacaktır ( ) 1

10) Saat kaç civarında kendinizi yorulmuş hissediyorsunuz ve uykunuz geliyor?

- Gece8:00 - Gece 9:00 ( ) 5
- Gece 9:00 - Gece 10:15 ( ) 4
- Gece 10:15 - Gece yarısından sonra 12:45 ( ) 3

- Gece yarısından sonra 12:45 - Sabah 02:00 ( ) 2
- Sabaha karşı 02:00 - Sabah 03:00 ( ) 1

11) Bir güne ait planlarınızı tam olarak kendinizin ayarladığını düşünün. Size, iki saat sürecek ve sonunda zihinsel olarak yorgun düşürecek bir başarı testi uygulanacak olsa en iyi performansı gösterebilmeniz için bu testin hangi saat diliminde uygulanması sizce uygun olur?

- Sabah 08:00 - 10:00 ( ) 4
- Sabah 11:00 - 13:00 ( ) 3
- Öğleden sonra 15:00 - 17:00 ( ) 2
- Akşam 19:00 - 21:00 ( ) 1

12) Gece saat 23.00'de yattığınızı düşünün. Yatağa yattığınızda kendinizi ne düzeyde yorgun hissedersiniz?

- Hiç yorgun hissetmem ( ) 0
- Çok az yorgun hissederim ( ) 2
- Oldukça yorgun hissederim ( ) 3
- Çok fazla yorgun hissederim ( ) 5

13) Birtakım nedenlerden ötürü her zamankinden 3-4 saat daha geç yattığınızı ancak ertesi sabah belli bir saatte kalkmanız gerekmediğini düşünün. Aşağıdakilerden hangisi yatış ve kalkış zamanınızı en iyi tanımlar?

- Her zamanki vakitte uyanırım ve tekrar uyumam ( ) 4
- Her zamanki vakitte uyanırım ama daha sonra hafifçe uyuklarım ( ) 3
- Her zamanki vakitte uyanırım ama tekrar uykuya dalarım ( ) 2
- Her zamankinden geç uyanırım ( ) 1

14) Sabah 04:00-06:00 arası nöbet tuttuğunuzu ve uyanık durmak zorunda olduğunuzu düşünün. Ertesi güne ait bir randevunuz da yok. Böyle bir durumda aşağıdakilerden hangisini yaparsınız?

- Nöbet bitene kadar yatmam ( ) 1
- Nöbetten önce hafif bir şekerleme yapar ve nöbetten sonra uyurum ( ) 2
- Nöbetten önce uyur nöbetten sonra da biraz kestiririm ( ) 3
- Nöbetten önce iyice uyur ve uykumu almış olurum ( ) 4

15) İki saat bedensel olarak sıkı bir şekilde çalışmak zorunda olduğunuzu düşünün. Günlük çalışma planınızı ayarlamakta da tamamıyla serbest olsanız aşağıdaki zaman dilimlerinden hangisi sizin için en iyi çalışma zamanıdır?

- Sabah 08:00 - 10:00 ( ) 4
- Sabah 11:00 - Öğleden sonra 13:00 ( ) 3

- Öğleden sonra 15:00 - 17:00 ( ) 2
- Akşam 19:00 - 21:00 ( ) 1

16) Sıkı bir fiziksel egzersiz yapmaya karar verdiniz. Bir arkadaşınız da bunu haftada iki kez ve birer saat yapmanızın uygun olduğunu belirterek bunun için en iyi zamanın gece 22:00 23:00 arası olduğunu söyledi. Bu saatlerde en iyi performansını gösterebilir misin?

- İyi bir şekilde gerçekleşeceğini düşünürüm ( ) 1
- Orta derecede başarılı olurum ( ) 2
- Güç olacaktır ( ) 3
- Çok güç olacaktır ( ) 4

17) Çalışma saatlerinizi kendinizin belirlediğinizi düşünün. Günde 5 saat (yemek arası dahil) çalıştığınızı, işinizin ilginç bir iş olduğunu, severek çalıştığınızı ve elde ettiğiniz başarıya göre de ücret aldığınızı farz edin. Böyle bir durumda 5 saatlik çalışma sürenizi başlatmak için hangi saatleri seçerdiniz?

- Sabah 04:00 - Sabah 08:00 ( ) 5
- Sabah 08:00 - Sabah 09:00 ( ) 4
- Sabah 09:00 - Öğleden sonra 14:00 ( ) 3
- Öğleden sonra 14:00 - Öğleden sonra 17:00 ( ) 2
- Öğleden sonra 17:00 - Sabah 04:00 ( ) 1

18) Gün içinde kendinizi en iyi hissettiğiniz zaman dilimi hangisidir?

- Sabah 05:00 - Sabah 08:00 ( ) 5
- Sabah 08:00 - Sabah 10:00 ( ) 4
- Sabah 10:00 - Öğleden sonra 17:00 ( ) 3
- Öğleden sonra 17:00 - Gece 22:00 ( ) 2
- Gece 22:00 - Sabah 05:00 ( ) 1

19) İnsanlar yaşam biçimleri, uyku-uyanıklık düzenleri ve gösterdikleri performansların zamanı bakımından “sabah tipi” ve “akşam tipi” şeklinde sınıflandırılabilirler. Aşağıdakilerden hangisi bu bakımdan sizi en iyi şekilde tanımlar?

- Kesinlikle sabah tipiyim ( ) 6
- Akşam tipinden daha çok sabah tipine uyuyorum ( ) 4
- Sabah tipinden daha çok akşam tipine uyuyorum ( ) 2
- Kesinlikle akşam tipiyim ( ) 0

APPENDIX G- The Richards-Campbell Sleep Questionnaire (RSCQ)

Haftalık Çalışma Öncesi Anket

Katılımcı: ………….

- Dün gece saat kaçta uyudunuz?

……………………………………………………………………………………

- Bu sabah saat kaçta uyandınız?

……………………………………………………………………………………

RİCHARD-CAMPBELL UYKU ÖLÇEĞİ

Aşağıdaki ölçeği, dün geceki uyku durumunuzu düşünerek '0 **en kötü'** ve '100 **en iyi'** olacak şekilde değerlendirmeniz istenmektedir. Her bir maddeyi dikkatlice okuyup size uygun olan derecenin olduğu kutucuğu işaretleyiniz.

Uyku Kalitesi	**Değerlendirme**										
	0	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1) Dün gece uykum											
2) Dün gece uykuya dalmam											
3) Dün gece uyanma sıklığı											
4) Dün gece uyanık kalma süresi											
5) Dün gece uykunun kalitesi											
6) Dün gece gürültü seviyesi											

APPENDIX H- Ethical Board Approval

SAYI : B.30.2.İEÜ.0.05.05-**020**-*267* 28.02.2023

KONU : Etik Kurul Kararı hk.

Sayın Prof. Dr. Canan Başar Eroğlu ve Kübra Altuntaş,

"Genç Yetişkinlerde, Egzersiz ve Sirkadiyen Ritmin (Sabahçıl-Akşamcıl) Çalışma Belleği Üzerindeki Etkisi" başlıklı projenizin etik uygunluğu konusundaki başvurunuz sonuçlanmıştır.

Etik Kurulumuz 28.02.2023 tarihinde sizin başvurunuzun da içinde bulunduğu bir gündemle toplanmış ve Etik Kurul üyeleri projeleri incelemiştir.

Sonuçta 28.02.2023 tarihinde **"Genç Yetişkinlerde, Egzersiz ve Sirkadiyen Ritmin (Sabahçıl-Akşamcıl) Çalışma Belleği Üzerindeki Etkisi"** konulu projenizin etik açıdan uygun olduğuna oy birliğiyle karar verilmiştir.

Gereği için bilgilerinize sunarım.

Saygılarımla,

Prof. Dr. Murat Bengisu

Etik Kurul Başkanı