Constructor University
School of Business, Social, & Decision Sciences

Promoting Physical Activity on University Students

B.Sc. Thesis in Integrated Social and Cognitive Psychology

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by

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Abstract

Physical inactivity poses a significant public health challenge among university students, with many failing to meet recommended physical activity levels. Message framing, the way information is presented, has emerged as a promising tool for promoting behavior change. This study aims to investigate the effectiveness of gain-framed and loss-framed messages compared to a control group in promoting physical activity frequency and to examine whether self-efficacy and attitudes toward physical activity act as a moderator variable in this relationship. Through a randomized controlled trial, the participants ($N = 87$) were allocated into three groups: gain-framed, loss-framed, and control. Participants completed a pre-intervention questionnaire, after which they received tailored messages for one month, and were followed up with a post-intervention questionnaire. Results revealed no significant difference in physical activity frequency between the gain-framed, loss-framed, and control groups. Furthermore, hierarchical regression analyses showed that neither self-efficacy nor attitudes toward physical activity significantly moderated the relationship between message framing and physical activity behavior. This suggests a need for further exploration of intervention strategies to effectively promote physical activity among university students.

Contents

Chapter 1

Introduction

Regular physical activity is widely recognized as a fundamental element of human health, as it has profound effects on mental and physical well-being (Warburton, 2006). Despite these benefits, a significant portion of the global population fails to meet recommended activity levels (Hallal et al., 2012). Research has shown that participation in physical activity varies across different societal groups and can change throughout one's lifetime (Engberg et al., 2012). Young individuals going through a transitional stage, especially those moving from high school to college, are affected by physical inactivity. In particular, studies have shown that students in this phase often experience a decrease in physical activity (Engberg et al., 2012). This decline has been attributed to various factors, including adapting to a new lifestyle, increased academic workload, and the absence of mandatory physical education classes that were present in high school. (Arzu, Tuzun, & Eker, 2006)

The youth's physical inactivity levels are a societal concern since individuals that begin exercising at a young age are more likely to maintain that habit later in life (Telama et al., 2005) and proceed to instill it in their children (Rodríguez-Rodríguez, Huertas-Delgado, Barranco-Ruiz, Aranda-Balboa, & Chillón, 2020). For example, children with active parents are estimated to be three to four times more

active than children with inactive parents (Sims & Bopp, 2019). This ripple effect could significantly contribute to combating the obesity pandemic, a major public health concern responsible for numerous deaths annually.

In response to this current challenge, researchers have increasingly focused on intervention strategies to motivate the youth to be active. One promising approach is using message framing based on prospect theory (Kahneman & Tversky, 1979). Essentially, prospect theory states that individuals perceive gains and losses differently. Messages can be framed in terms of potential gains or losses, with gain-framed messages highlighting the benefits of engaging in a behavior, while loss-framed messages emphasize the consequences of not doing so. Message framing has been used widely in health communication interventions, in areas such as smoking cessation (Toll et al., 2007), social distancing during COVID (Ceylan & Hayran, 2021), or oral hygiene (Divdar, Araban, Heydarabadi, Cheraghian, & Stein, 2021).

While previous research has shown the efficacy of message framing in promoting health behaviors, significant gaps persist in our understanding of the underlying mechanisms driving this effectiveness. This study seeks to address these gaps by examining the potential mediating role of *self-efficacy* and *attitudes towards physical activity* in the relationship between message framing and physical activity among university students.

To measure changes in physical activity behavior, participants were allocated into three message-framing groups (gain-framed, loss-framed, and control). Then, pre- and post-intervention questionnaires were used to measure the participants' physical activity.

This research aims to contribute to the development of specific interventions tailored to promote physical activity among college students. By understanding the mechanisms through which gain-loss messages influence physical activity, and iden-

tifying the role of attitudes and self-efficacy in this process, more effective methods will hopefully be developed.

Chapter 2

Theoretical Background

Regular physical activity is essential for maintaining a healthy lifestyle and preventing chronic diseases such as type 2 diabetes, stroke, and heart disease (Lee et al., 2012). In fact, the World Health Organization (WHO) identifies physical inactivity as a significant risk factor, alongside smoking, obesity, and hypertension (WHO, 2009). Furthermore, physical inactivity ranks as the fourth leading risk factor for noncommunicable diseases, contributing to over 3 million preventable deaths worldwide (WHO, 2009). Research indicates that 6–10% of all deaths from noncommunicable diseases can be attributed to physical inactivity, with certain diseases like heart disease-bearing a heavier burden (Lee et al., 2012). The benefits of physical activity extend to preventing 35 chronic conditions (Booth, Roberts, & Laye, 2012) and improving overall well-being by reducing symptoms of depression and anxiety (Chan et al., 2018) and enhancing thinking, learning, and judgment skills (Baek, 2016). Despite these benefits, many individuals fail to meet the recommended physical activity levels (Hallal et al., 2012).

Recommendations from WHO and other organizations such as NHS suggest 150 minutes of moderate-intensity physical activity or 75 minutes of vigorous physical activity per week for adults. Moderate-intensity activities include increasing heart

rate to 60-70% of maximal heart rate or 3-6 metabolic equivalents (METs), while vigorous activities entail raising heart rate to 70-85% of maximal heart rate or greater than 6 METs.

Despite these guidelines, approximately three out of every ten individuals aged 15 years or older fail to meet them, amounting to roughly 1.5 billion people globally (Hallal et al., 2012). The situation is even more concerning among adolescents with an estimated four out of every five failing to meet the guidelines (Hallal et al., 2012).

College students represent a demographic group particularly susceptible to decreased physical activity levels. Research indicates that transitioning to university often leads to a decline in physical activity among students (Kwan, Cairney, Faulkner, & Pullenayegum, 2012; Edelmann et al., 2022). Several factors contribute to the decline in physical activity among college students, including academic pressure, time constraints, and changes in living environments (Arzu et al., 2006) These environmental and lifestyle changes can significantly impact students' ability to maintain healthy habits. Research by Butler and colleagues (2004) demonstrated a significant increase in sedentary behavior among college students, leading to weight gain and unhealthy dietary habits. Furthermore, studies estimate that a significant portion of university students are physically inactive or do not engage in recommended levels of physical activity (Suminski, Petosa, Utter, & Zhang, 2002). However, regular physical activity is crucial for college students' well-being. It not only helps to alleviate stress but also provides opportunities for social interaction and community engagement (Pascoe & Parker, 2018; Di Bartolomeo & Papa, 2017)). Additionally, it can positively impact academic performance by boosting blood flow and oxygen to the brain, fueling focus, memory, and learning(Erickson et al., 2011).

Despite the recognition of the importance of healthy behaviors during young adulthood, research indicates that these behaviors often decline during the young adult-

hood transition (Frech, 2012)). Furthermore, habits developed during early adulthood, including physical activity patterns, are likely to persist into later stages of life (Telama et al., 2005) Consequently, there is a pressing need for targeted interventions to promote health-enhancing behaviors among college students.

When designing interventions to promote health behaviors, such as physical activity, developing persuasive messages that motivate individuals to consistently engage in these behaviors is crucial. Drawing upon research in social cognition, various strategies for developing persuasive messages have been proposed (Petty & Cacioppo, 1986; Joule, Girandola, & Bernard, 2007). For this investigation, I turned to Prospect theory as a guiding framework for the design of our messages (Kahneman & Tversky, 1979).

Prospect theory suggests that individuals respond differently to information based on how it is presented (Kahneman & Tversky, 1979). Messages can be framed either in terms of potential gains (benefits) or losses (costs). An example of a gain-framed message might be: "Engaging in regular physical activity increases your likelihood of leading a long, healthy life." In contrast, loss-framed messages emphasize the negative consequences of failing to adopt the desired behavior. For instance, a loss-framed message could state: "Not engaging in regular physical activity increases your risk of developing chronic health conditions. Furthermore, this theory posits that individuals exhibit different risk preferences depending on whether potential gains or losses are emphasized (Kahneman & Tversky, 1979). When presented with messages highlighting potential gains, people tend to be risk-averse, meaning they are inclined to avoid taking risks. Conversely, when messages emphasize potential losses, individuals become risk-seeking, meaning they are more willing to take risks to avoid negative outcomes. Another factor influencing the effectiveness of message framing is the nature of the health behavior being promoted. Health behaviors can be broadly categorized into prevention behaviors and detection behaviors. Prevention behaviors,

such as wearing sunscreen to reduce the risk of skin cancer, are perceived as low-risk activities with potential long-term benefits. On the other hand, detection behaviors, such as cancer screenings, are perceived as riskier due to the possibility of uncovering health issues (Rothman & Salovey, 1997). According to prospect theory, individuals are more inclined to adopt riskier options when considering losses. Therefore, the performance of detection behaviors, which involve a higher perceived degree of risk, should be best facilitated by a loss-framed message (Williams, Clarke, & Borland, 2001). In contrast, prevention behaviors, which are perceived as less risky, are better suited to gain-framed messages. For example, gain-framed messages emphasizing the benefits of sunscreen use may be more effective in promoting this prevention behavior, as individuals are more likely to respond positively to messages highlighting potential gains in health outcomes (Divdar et al., 2021; Detweiler, Bedell, Salovey, Pronin, & Rothman, 1999).

Several studies have demonstrated the efficacy of message framing in promoting physical activity, with gain-framed messages generally proving more successful than loss-framed (Fetter et al., 2019). For instance, a study by (McCall & Ginis, 2004) implemented gain-framed and loss-framed messages to promote exercise among participants. Those in the gain-framed condition received information emphasizing the benefits of exercise in preventing the progression of coronary artery disease (CAD), while those in the loss-framed condition received the same information presented in a manner highlighting the risks of not exercising. The control group did not receive any information. The messages were crafted according to established guidelines for developing gain- and loss-framed health messages (Detweiler et al., 1999). This study served as a foundational reference for our own intervention design.

However, an important gap remains in our understanding of the underlying mechanisms driving the effectiveness of message fraiming and physical activity. This study aims to address this gap by investigating the potential moderating role of *self-efficacy*

and *attitudes* toward physical activity in the relationship between message framing and exercise behavior. Before explaining the concepts of attitudes and self-efficacy, it is necessary to define a moderator. A moderator is a variable, either qualitative (e.g., sex, race, class) or quantitative (e.g., level of reward), that influences the direction and/or strength of the relationship between an independent or predictor variable and a dependent or criterion variable (Baron & Kenny, 1986).In this study, I aim to explore how self-efficacy and attitude toward physical activity may moderate the relationship between message framing and exercise behavior. By investigating these moderating factors, I seek to gain deeper insights into the mechanisms underlying the effectiveness of message framing in promoting physical activity.

Self-efficacy, as conceptualized by (Bandura, 1977)refers to an individual's belief in his or her capacity to execute behaviors necessary to produce specific performance attainments , and it has been shown to be a robust predictor of the adoption and maintenance of health behaviors, including physical activity (RGN & RGN, 2002). Some studies have shown that control cognitions, including self-efficacy, predict intentions to engage in health-related behaviors and actual behavior. In essence, individuals with higher self-efficacy are more likely to consistently engage in physical activity (Foley et al., 2008). However, further research suggests that the relationship between message framing and self-efficacy is not straightforward: in particular, individuals with high self-efficacy have been shown to respond better to loss-framed messages (Riet, Ruiter, Werrij, & de Vries, 2008), which suggests the precise model cannot be linear.

Attitudes can be defined as individuals' overall evaluations or feelings toward specific objects, people, or situations(Olson & Zanna, 1993). In the context of physical activity, attitudes refer to individuals' positive or negative evaluations of engaging in exercise or other forms of physical activity. Existing studies based on the Theory of Planned Behavior have primarily predicted exercise behavior through instrumen-

tal attitudes, which encompass cognitive convictions about the benefits of physical exercise("http://dx.doi.org/10.7752/jpes.2014.04087", 2014). However, more recent research has highlighted the significance of affective attitudes toward exercise(Lawton, Conner, & McEachan, 2009), which involve individuals' emotional responses to the idea of engaging in physical activity. These affective attitudes, such as whether thinking about doing physical exercise makes one feel comfortable or uncomfortable, have demonstrated equal or even greater success in explaining exercise behavior compared to instrumental attitudes(Lawton et al., 2009). This suggests that individuals' emotional reactions and comfort levels regarding physical activity play a role in influencing their exercise intentions and behaviors. Moreover, studies have shown that proximal outcome expectancies related to immediate emotional rewards or benefits experienced during exercise are more predictive of exercise intention and behavior than distal outcome expectancies like future health benefits (Gellert, Ziegelmann, & Schwarzer, 2012).

Thus, by examining whether and how self-efficacy and attitudes toward physical activity moderate the effects of message framing on physical activity, this research aims to enlighten the intricate interaction between self-efficacy, attitudes, and message framing and contribute valuable insights for the design and implementation of targeted and effective interventions tailored specifically for university students.

Message framing was manipulated as the independent variable, presenting information either in gain-framed (highlighting benefits) , loss-framed (emphasizing costs) messages, or, in the case of the control condition, participants did not receive any message. Physical activity served as the dependent variable, measured by the total metabolic equivalent of task (METS) among participants. To mitigate potential confounding variables, participants' demographic characteristics (such as age, gender, and BMI), prior exercise habits, and health conditions were assessed.

Therefore, based on the relationship of all the aforementioned variables, it is hypothesized:

H1: Participants exposed to gain-framed messages will increase their levels of physical activity compared to those exposed to loss-framed messages.

H2: Self-efficacy will moderate the relationship between message framing and physical activity.

H3: Attitudes toward physical activity will moderate the relationship between message framing and physical activity.

Chapter 3

Methods

3.1 Sample

The participants in this experiment consisted of university students aged between 18 and 25 years old. This demographic was chosen to align with the study's focus on changing the physical activity behavior of college students. The initial sample size was 101 participants, but due to dropouts during the study, the final sample size was reduced to $N = 88$. Participants were randomly assigned to one of three groups: gain-framed, loss-framed, or control, with each group comprising approximately 30 participants. Characteristics of the study sample are presented in Table 3.1.

Table 3.1: Characteristics of the Study Sample Across the Three Experimental Conditions

Demographic		Gain-Framed	Loss-Framed	Control
Gender	Male	12	13	19
	Female	15	18	10
	Transgender	0	1	0
Age	18-20	4	8	5
	21-23	21	23	23
	≥ 24	2	1	1
Highest Degree	High School	18	18	17
	Bachelor's	9	13	12
	Doctoral's	0	2	0
Continent	America	14	24	18
	Europe	8	4	8
	Africa	3	0	1
	Asia	2	4	2
Pre-existing Conditions	Yes	0	3	2

3.2 Materials and data collection method

The data collection process for this study involved administering two online questionnaires, one conducted before the intervention (T_1) and the other after (T_2). These questionnaires were created using Google Forms to facilitate ease of administration and data management.

For the pre-intervention questionnaire, participants were directed to provide informed consent, outlining the study's objectives, procedures, and potential risks and benefits. Subsequently, data on control variables, including basic demographics (age,

nationality, gender, academic major), disability status, and type of physical activity (teams or individually), were gathered.

In the next section, the participants' baseline attitudes towards physical activity, self-efficacy, and physical activity levels were measured. The New General Self-Efficacy Scale (Chen, Gully, & Eden, 2001) was employed to assess the individual's overall confidence in his or her ability to cope with tasks and overcome obstacles. Additionally, I created supplementary items tailored specifically for students and their engagement in physical activity. These items drew inspiration from the Exercise Self-Efficacy Scale (ESES) (Kroll, Kehn, Ho, & Groah, 2007) but were refined to better resonate with the distinct challenges and opportunities encountered by students in their pursuit of physical activity.

Furthermore, the International Physical Activity Questionnaire (IPAQ) (Hagströmer, Oja, & Sjöström, 2006) was implemented to assess the participants' physical activity levels. The IPAQ is a standardized tool for measuring physical activity levels across diverse populations and cultural contexts. Craig and colleagues (2003) conducted reliability and validity assessments across 12 nations for the IPAQ, demonstrating its consistency in generating data. There are two versions of IPAQ: a short and a long version. Due to time constraints, I decided to use the short version for this study. The short version is designed for studies with limited time and comprises 8 items to estimate the time spent on physical activities (moderate to vigorous) and sedentary behavior (time spent sitting) during the last 7 days. The time frame was adjusted from "last 7 days" to "last month" to analyze the one-month gap between questionnaire administrations (T_1 and T_2). Total physical activity results were measured using metabolic equivalents (METs) as the unit, with one MET signifying an oxygen uptake of 3.5 mL/kg/min during rest, equivalent to an energy expenditure of 1 kcal/kg per hour. Walking was valued as 3.3 METs, while Moderate-intensity physical activities were valued as 4 METs, and high-intensity activities were valued as

8 METs. High-intensity activities typically exhibit approximately twice the intensity of moderate-intensity ones.

Thus, the total physical activity is given by the following formulas:

Walking MET-minutes/week = 3.3 × average walking minutes per day × 7

Moderate MET-minutes/week = 4.0 × average minutes per day × moderate activity days

Vigorous MET-minutes/week = 8.0 × average minutes per day × vigorous activity days

The total physical activity MET-minutes/week score was then obtained by summing the Walking, Moderate, and Vigorous MET-minutes/week scores.

Lastly, the final items dealt with attitudes toward physical activity. Participants attitudes were evaluated using four categories: difficulty, relaxation, enjoyment, and healthiness. These categories were taken from Poobalan and colleagues' (2012) study, and based on their categories, I developed my questionnaire items. Responses were recorded on a 5-point scale ranging from 1 (disagree) to 5 (agree).

Overall, the first questionnaire aimed to control for potential influences on physical activity, and to establish baseline levels of self-efficacy, attitudes toward physical activity, and physical activity frequency among participants before the intervention.

The post-intervention questionnaire, conducted after the intervention period, closely resembled the pre-intervention questionnaire. Self-efficacy, attitudes toward physical activity, and physical activity frequency were measured again, and an additional intervention evaluation section was included for the groups that received targeted messages. In this section, participants were also asked to evaluate their perceived intervention's effectiveness. The full questionnaire is available in Appendix B.

The use of validated scales and comprehensive questionnaires ensured the reliability and validity of the collected data. By administering pre- and post-intervention

questionnaires, the aim was to assess physical activity levels over time, providing valuable insights into the effectiveness of the intervention.

Regarding the intervention material, participants in both the gain and loss-framed conditions received a series of 10 emails throughout 30 days outlining the advantages of physical activity. Conversely, the control group did not receive any emails. The content of these messages (presented in Table C.1) was adapted from a study by McCall (2004) but tailored to suit university students rather than patients in a cardiac rehabilitation program (which were the subjects of McCall's original paper).

3.3 Procedure

To ensure a diverse and representative sample, I employed a combination of convenience and snowball sampling techniques. Initially, convenience sampling targeted students aged 18 to 25 from Constructor University, aligning with our study's focus. However, encountering challenges during recruitment prompted me to supplement the approach with snowball sampling. This method allowed me to contact my personal connections from Colombia. I expanded our participant pool by reaching out to my network of high school alumni who are current university students.

To optimize survey response rates, I attached the questionnaire to the first email sent to all prospective participants to enable immediate participation in case of consent. This approach aimed to facilitate widespread participation and enhance the sample's representation.

Participants received an email containing a link to the initial questionnaire and consent form. After providing consent and completing the questionnaire, participants were randomly allocated to one of the three groups: gain-framed, loss-framed, or control. Participants allocated to the gain-framed and loss-framed groups received framed messages via email every three days for a total of 10 emails over 30 days (Shown

in Table C.1). After 30 days, all participants received a final email requesting them to complete the final questionnaire to measure physical activity, attitudes toward physical activity, and self-efficacy. The study was conducted in adherence to ethical guidelines, ensuring participants' confidentiality throughout the process.

This procedure was implemented using Google Forms in conjunction with a Python script (See the code in Appendix D). The Python script was developed to automate the process of sending email messages to participants according to their assigned groups and the scheduled frequency, as well as to use the (pseudo) random number generator to allocate participants to their groups. This script utilized libraries like smtplib and pandas to establish secure communication with the email server, manage message delivery, and store data frames.

3.4 Data Analysis

All data analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 25.0.

First, to measure the effectiveness of the intervention and changes in behavior, a repeated measures ANOVA was performed comparing physical activity levels at Time 1 (T_1) and Time 2 (T_2) across different groups based on message framing type. Here, the time period is a within-subjects factor, while the intervention group is a between-subjects factor.

For moderation analysis, we followed the statistical recommendations outlined by (Baron & Kenny, 1986). Moderation analysis examines whether the relationship between an independent variable (IV) and a dependent variable (DV) is influenced by the presence of a moderator variable (or variables). In our study, we investigated the moderation effects of self-efficacy and attitudes toward physical activity on the

relationship between message framing (IV) and changes in physical activity frequency (DV).

Letting Y label the difference in physical activity between T_1 and T_2, X the message-framing group, M_1 the self-efficacy, and M_2 the attitudes towards exercise, the moderation model we employed (see Fig. 3.1) is based on the following equation:

$$Y = \beta_0 + \beta_1 X + \beta_2 M_1 + \beta_3 M_2 + \beta_4 (X \cdot M_1) + \beta_5 (X \cdot M_2) + \varepsilon \tag{3.1}$$

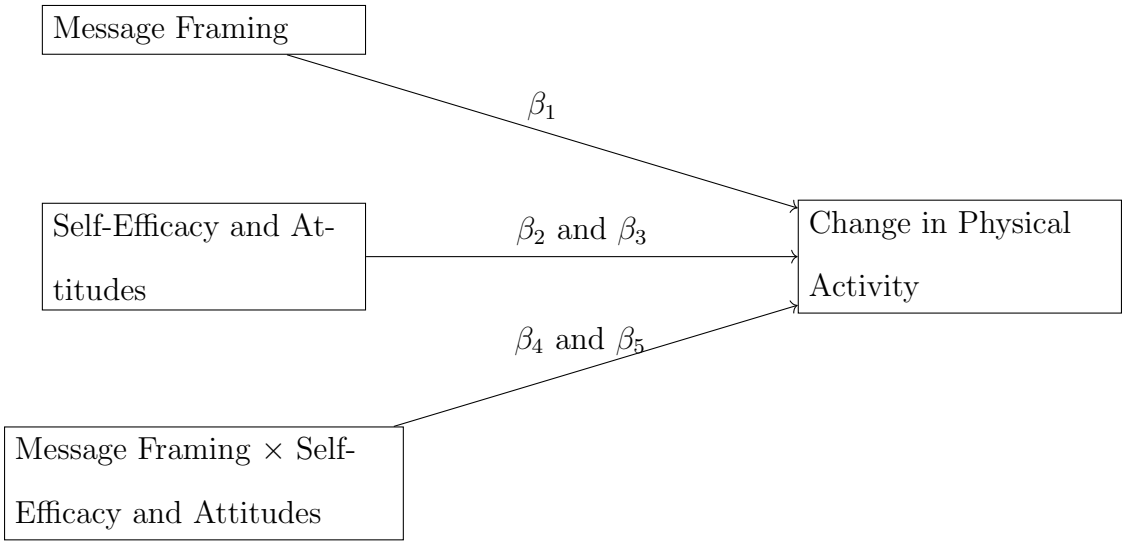

Figure 3.1: Moderation model

Several transformations were necessary to prepare the data for analysis. Firstly, the categorical variable representing message-framing group type was converted into an ordinal variable using dummy coding. Specifically, since the message-framing group variable X had $k = 3$ possible categories, I encoded it as $k - 1 = 2$ binary

variables X_1 and X_2. Here, X_1 and X_2 take the following values:

$$(X_1, X_2) = \begin{cases} (1,0) \text{ if } X = \text{Gain Fraiming} \\ (0,1) \text{ if } X = \text{Loss Fraiming} \\ (0,0) \text{ if } X = \text{Control} \end{cases} \tag{3.2}$$

Additionally, the moderator variables, self-efficacy and attitudes, underwent a transformation process to create mean-centered variables. This process involves subtracting the mean value of each variable from individual scores in the dataset. Mean-centering serves to mitigate multicollinearity issues and facilitates the interpretation of interaction effects in regression models, in particular for moderation models (Hofer, 2017).

Furthermore, the dependent variable Y, representing the difference between physical activity frequencies measured at T_1 and T_2, was treated as a continuous variable in the analysis. After the transformation of variables, the new model is depicted by

$$\begin{aligned} Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 M_1 + \beta_4 M_2 + \beta_5 (X_1 \cdot M_1) \\ + \beta_6 (X_2 \cdot M_1) + \beta_7 (X_1 \cdot M_2) + \beta_8 (X_2 \cdot M_2) + \varepsilon \end{aligned} \tag{3.3}$$

It should be noted that no interactions containing $(M_1 \cdot M_2)$ have been included, as there is no a-priori theoretical reason to suspect that the interaction between attitude towards exercise and self-efficacy may influence the change in physical activity significantly.

A hierarchical multiple regression analysis was performed to examine the incremental variance explained by the moderators — self-efficacy and attitudes toward physical activity — in predicting the difference in physical activity between T_1 and T_2. The incremental variance explained by each set of predictors was assessed by

systematically adding variables to the regression model. The results to this analysis are presented in Section 4

Chapter 4

Results

Repeated measured analysis of variance

A repeated measures analysis of variance (ANOVA) was conducted to examine the effects of our intervention on total physical activity. The time period of measurements (pre vs. post-intervention) was used as the within-subjects factor, and the group (Control, Gain-framed, Loss-framed) was used as the between-subjects factor. The means and standard deviations for physical activity for each time period for measurement and group are presented in Table 4.1.

Descriptive Statistics

	Group	Mean	Std. Deviation	N
Total Activity per week T1	1	2620.19	1371.149	27
	2	3136.72	1550.785	32
	3	3320.17	1987.057	29
	Total	3038.69	1665.483	88
Total Activity per weekT2	1	2428.70	1438.824	27
	2	3344.69	2105.239	32
	3	2969.48	1478.096	29
	Total	2940.00	1744.338	88

Figure 4.1: Descriptive statistics on repeated measures

Regarding the effect of the time period as a within-subject factor, it was found that the effect of the time period on physical activity was not significant, with $F(1, 85) = 0.51$, $p = .477$, and partial $\eta^2 = .006$.

Similarly, the combined effect of the time period and framing group on physical activity was also not significant, with $F(2, 85) = 1.19$, $p = .309$, partial $\eta^2 = .027$. See results Table. A.1 These results' implications and possible explanations are discussed in Section 5.

Post-hoc pairwise comparisons with a Least Significant Difference adjustment indicated that there were no significant changes in physical activity over time for any group. In particular, the p-values are $p = .498$ for gain framing, $p = .423$ for loss framing, and $p = .199$ for control. See Fig. A.2

Hierarchical Regression

Next, I tested whether different models accounting for different variables can significantly predict total physical activity.

In Table 4.1, attitudes towards physical activity was used as a moderator variable.

Initially, the control variables did not significantly explain the variance in the change in physical activity. The addition of the message-framing group to the model did not improve the model fit significantly either. When attitudes towards physical activity were included as a predictor, the model's explanatory power (adjusted R^2) decreased slightly, indicating that attitudes did not significantly contribute to explaining the change in physical activity. Lastly, adding the interactions between the moderator and the message-framing variable did not significantly improve the model's predictive accuracy.

Overall, none of the models showed significant improvement or predictive power, and none of the β coefficients reached statistical significance. This suggests that

attitudes toward physical activity do not play a significant moderating role in this context. The detailed results can be found in Table 4.1.

Table 4.1: Hierarchical Regression Using Attitudes as a Moderator

	Model 1				Model 2				Model 3				Model 4			
Variable	*b*	SE	β	*p*	*b*	SE	β	*p*	*b*	SE	β	*p*	*b*	SE	β	*p*
Intercept	-3017.045	2580.234		.246	-3616.425	2619.198		.171	-3399.625	2717.501		.215	-3259.140	2830.307		253
Age	125.910	117.579	.119	.287	144.116	118.129	.136	.226	133.725	123.044	.126	.280	127.575	127.951	.120	.322
Gender	414.964	324.467	.142	.204	348.066	329.583	.119	.294	350.219	331.464	.120	.294	354.088	342.490	.121	.304
Gain					135.740	399.182	.043	.735	154.976	405.758	.049	.704	157.117	417.943	.050	.708
Loss					556.067	389.093	.182	1.57	556.804	391.241	.182	1.59	544.660	402.806	178	.180
Attitudes									88.887	274.692	.037	.747	16.155	466.942	.007	.972
Attitudes × Loss													89.556	654.845	.023	.892
Attitudes × Gain													153.246	713.53	.033	.830
Variance Explained	$R^2 = .003$, $p = .328$				$R^2 = .006$, $p = .347$				$R^2 = -.005$, $p = .474$				$R^2 = -.030$, $p = .717$			
Change in *R*	$\Delta R^2 = .026$, $p = .328$				$\Delta R^2 = .026$, $p = .328$				$\Delta R^2 = .001$, $p = .747$				$\Delta R^2 = .001$, $p = .977$			

This analysis was repeated, now using self-efficacy as the moderator variable. Adding self-efficacy as a variable led to a non-significant improvement of the fit with an adjusted R^2 close to zero. This suggests that self-efficacy alone did not significantly explain the variance in changes in physical activity. The addition of interaction terms between the message-framing variable and self-efficacy also did not significantly improve, with the adjusted R^2 remaining near zero. See Table 4.2.

Table 4.2: Hierarchical Regression Using Self Efficacy as a Moderator

	Model 1				Model 2				Model 3				Model 4			
Variable	*b*	SE	β	*p*	*b*	SE	β	*p*	*b*	SE	β	*p*	*b*	SE	β	*p*
Intercept	-3017.045	2580.234		.246	-3616.425	2619.198		.171	-3539.663	2608.916		.190	-3768.595	2706.649		.168
Age	125.910	117.579	.119	.287	144.116	118.129	.136	.226	140.308	121.199	.132	.250	151.391	122.403	.143	.220
Gender	414.964	324.467	.142	.204	348.066	329.583	.119	.294	357.250	336.493	.122	.292	408.641	337.733	.140	.230
Gain					135.740	399.182	.043	.735	141.753	403.330	.045	.726	88.454	407.542	.028	.829
Loss					556.067	389.093	.182	1.57	551.407	392.508	.180	.164	483.554	394.296	.158	.224
Self-Efficacy									42.459	265.430	.018	.873	-448.024	459.026	-.193	.332
Self-Efficacy × Loss													907.575	599.622	.255	.134
Self-Efficacy × Gain													387.275	682.401	.085	.572
Variance Explained	$R^2 = .003$, $p = .328$				$R^2 = .006$, $p = .347$				$R^2 = -.006$, $p = .485$				$R^2 = -.002$, $p = .451$			
Change in *R*	$\Delta R^2 = .026$, $p = .328$				$\Delta R^2 = .026$, $p = .328$				$\Delta R^2 = .000$, $p = .873$				$\Delta R^2 = .027$, $p = .315$			

Table 4.3: Hierarchical Regression Using both Self Efficacy and Attitudes as Moderators

	Model 1				Model 2				Model 3				Model 4			
Variable	b	SE	β	p	b	SE	β	p	b	SE	β	p	b	SE	β	p
Intercept	-3017.045	2580.234		.246	-3616.425	2619.198		.171	-3403.884	2735.182		.217	-4736.324	2908.516		.108
Age	125.910	117.579	.119	.287	144.116	118.129	.136	.226	133.981	123.874	.126	.283	195.601	131.639	.184	.141
Gender	414.964	324.467	.142	.204	348.066	329.583	.119	.294	345.767	350.778	.118	.313	341.724	346.203	.117	.327
Gain					135.740	399.182	.043	.735	155.045	408.277	.049	.705	152.606	415.911	.048	.715
Loss					556.067	389.093	.182	1.57	559.369	395.726	.183	.161	533.885	401.511	.175	.188
Self-Efficacy									-22.245	349.586	-.010	.949	-663.890	547.087	-.286	.229
Attitudes									103.759	361.961	.043	.775	373.998	548.546	.155	.497
Self-Efficacy × Gain													325.103	877.477	.712	.712
Self-Efficacy × Loss													1618.805	527.629	.455	.054
Attitudes × Loss													-1121.531	895.196	-.291	.214
Attitudes × Gain													-40.453	902.136	-.009	.964
Variance Explained	$R^2 = .003$, $p = .328$				$R^2 = .006\, p = .347$				$R^2 = -.017\, p = .607$				$R^2 = -.016\, p = .572$			
Change in R	$\Delta R^2 = .026$, $p = .328$				$\Delta R^2 = .026$, $p = .328$				$\Delta R^2 = .001$, $p = .948$				$\Delta R^2 = .048$, $p = .403$			

Lastly, the hierarchical regression analysis was repeated using both attitudes and self-efficacy as moderating variables. Including these variables did not significantly enhance the model fit, as evidenced by a negative adjusted R^2. Furthermore, the introduction of interaction terms with both moderators did not yield a significant improvement, with the adjusted R^2 remaining negative. Moreover, the introduction of interaction terms failed to yield a significant improvement, with adjusted $R^2 = -.16$, $F(4, 76) = 1.019$, $p = .403$. Although the standardized β coefficients were non-significant, However, the coefficient accompanying $X_2 \cdot M_2$ (the interaction between the 'Loss' dummy variable and self-efficacy) was only marginally insignificant, taking values $\beta = .455$, $t = 1.956$, $p = .054$.

The results are shown in Table 4.3.

Exploratory Analysis

I reapplied this hierarchical regression analysis to the total physical activity in T_2 rather than the change in physical activity and disregarded the message-framing variables. Here, self-efficacy emerged as a significant predictor, with $p =< .001$ and a significant β coefficient ($p < 0.01$) with $\beta = .468$, demonstrating a positive relationship with physical activity levels. This finding suggests that individuals with higher levels of self-efficacy are more likely to engage in physical activity. On the other hand, adding attitudes toward physical activity as a further variable describing the model did not significantly change the explanatory power of the model. This can be seen in Table 4.4.

Table 4.4: Exploratory Analysis using Self-Efficacy and Attitudes as predictors for overall Physical Activity on Time 2

	Model 1				Model 2				Model 3			
Variable	*b*	SE	β	*p*	*b*	SE	β	*p*	*b*	SE	β	*p*
Intercept	4783.215	392.206		.126	7053.771	2820.682		.014	7601.737	2871.618		.010
Gender	-275.169	388.848	-.079	.481	2.688	354.415	.001	.994	-34.074	356.211	-.010	.924
Age	-78.510	140.909	-.062	.579	-190.204	128.861	-.151	.144	-214.765	131.101	-.171	.105
Self-Efficacy					1288.965	280.238	.468	**< .001**	1044.456	369.858	.379	.006
Attitudes									388.123	383.065	.136	.314
Variance Explained	$R^2 = -.016$, $p = .719$				**$\mathbf{R^2} = .181$, p =< .001**				**$\mathbf{R^2} = -.181$, , p =< .001**			
Change in R	$\Delta R^2 = .004$, $p = .579$				**$\boldsymbol{\Delta R^2} = .201$, $\boldsymbol{p} =< .001$**				$\Delta R^2 = .010$, $p = .314$			

Chapter 5

Discussion

This study investigated the effects of message framing on physical activity and explored the moderating roles of self-efficacy and attitudes toward physical activity among university students. Contrary to expectations and previous literature, participants who received gain-framed messages did not experience a significant increase in physical activity. Additionally, we found no evidence indicating a moderating effect of self-efficacy or attitudes between message framing and changes in physical activity.

The hierarchical regression analyses aimed to assess whether self-efficacy and attitudes toward physical activity moderated the relationship between message framing and exercise behavior. Results revealed that neither attitude toward physical activity nor self-efficacy significantly moderated this relationship. This suggests that individuals' beliefs about their capabilities to engage in physical activity (self-efficacy) and their attitudes toward physical activity did not influence their response to gain-framed or loss-framed messages. However, the interaction between the 'Loss' dummy variable and self-efficacy showed marginal insignificance, it suggests a potential trend for future exploration.

When examining total physical activity at a fixed time (chosen arbitrarily to be T_2) without considering message framing, self-efficacy emerged as a significant predic-

tor, indicating that individuals with higher self-efficacy are more likely to engage in physical activity. This finding aligns with Bandura's Social Cognitive Theory, emphasizing the importance of self-efficacy beliefs in driving behavior change. Conversely, attitudes toward physical activity did not significantly predict total physical activity at T_2 when self-efficacy was included in the model, suggesting that self-efficacy may play a more crucial role than attitudes in influencing physical activity levels among college students.

The lack of significant effects of time period and the interaction between time period and framing group on physical activity suggests that our intervention did not lead to significant changes in exercise behavior over time across different framing conditions. These results indicate that neither gain-framed nor loss-framed messages significantly impacted participants' physical activity levels compared to the control group.

Several limitations may have contributed to the non-significant findings in this study. First, participant engagement with the intervention material was low, with only 18% of participants in the gain and control groups reporting reading most of the emails. This indicates a clear need for improvements in the delivery system of intervention materials in future studies. However, it's worth noting that 34% of participants expressed a neutral sentiment toward the communication channel for delivering information about physical activity. This neutrality suggests that while some participants did not actively engage with the intervention material, they did not outright reject the communication channel either. Furthermore, participants offered valuable insights into alternative communication channels that could potentially improve engagement. Suggestions such as utilizing YouTube videos, Instagram stories, posters, seminars, and public spaces were proposed as alternatives to traditional email communication. Some participants explained their reluctance to engage with emails, stating that this communication channel is primarily used for work, applications, or

bills, and anything else is often overlooked. Therefore, future research should focus on identifying a communication channel more suitable to the sample. Participants suggested social media platforms as potential alternatives and, considering the high level of interaction among youth, incorporating social media platforms into intervention strategies may be a promising approach to enhance participant engagement.

Another factor that may explain the insignificance of results in the intervention is the short time frame between the pre-intervention and post-intervention questionnaires. Behavior change typically undergoes a gradual process that involves different phases, starting with the initiation phase, during which individuals select new behaviors and the contexts in which they will engage in them. Subsequently, automaticity develops during the learning phase, where behaviors are repeatedly performed in the chosen context to strengthen the association between the behavior and its context. This process eventually leads to the stability phase, where the habit has formed, and its strength plateaus, making it persist over time with minimal effort or deliberation (Gardner, Lally, & Wardle, 2012). Research suggests that habit formation takes time, with studies indicating that it takes more than two months, approximately 66 days on average, for a new behavior to become automatic. However, the time it takes for a habit to form can vary widely depending on factors such as the specific behavior, the individual, and their circumstances. For instance, it has been found that the time taken for people to form a new habit can range from 18 days to 254 days (Lally, van Jaarsveld, Potts, & Wardle, 2009).

Additionally, the timing of data collection, particularly in relation to participants' spring break, presents another limitation. During the final week of the study period, many participants were likely on spring break, a period characterized by disruptions to routine and changes in the environment. These alterations in their daily schedules and surroundings may have influenced their physical activity levels, making it challenging to assess the impact of our intervention accurately. Moreover, we administered the

second survey post-intervention immediately after spring break, which may have been sub-optimal as participants' recent experiences during the break may have overshadowed their ability to recall their physical activity-related behaviors accurately. Their attention and focus may have been primarily on their vacation activities rather than their exercise routines, potentially leading to recall bias and affecting the reliability of the data collected post-intervention.

Furthermore, the reliance on self-report measures to assess physical activity introduces inherent limitations, including the potential for recall bias and social desirability bias. Participants may overestimate or underestimate their physical activity levels, leading to inaccuracies in the data collected. Utilizing objective measures of physical activity, such as accelerometers or fitness trackers, could provide more reliable and valid data.

Future interventions aimed at promoting physical activity among university students should prioritize strategies to enhance self-efficacy. Bandura's recommendation is to design messages that increase individuals' awareness of the seriousness of inactivity to evoke a stronger sense of vulnerability. While our study did not explicitly target vulnerability perception, future interventions may benefit from incorporating it. Additionally, exploring alternative communication channels that align with student preferences could enhance message effectiveness and engagement. By adopting these approaches, researchers can refine intervention strategies to effectively promote physical activity behavior change among university students.

Chapter 6

Conclusion

This study explored the impact of message framing on college students' physical activity levels, as well as the potential moderating influences of self-efficacy and attitudes towards physical activity. Contrary to expectations, gain-framed messages did not appear to increase physical activity significantly compared to loss-framed or control conditions. Furthermore, neither self-efficacy nor attitudes toward physical activity significantly moderated this relationship. However, an important finding emerged: self-efficacy did show to be a significant predictor of total physical activity by itself. This underscores the importance of targeting self-efficacy in interventions aimed at promoting physical activity among college students.

Several limitations should be acknowledged, including participant dropout rates, low engagement with the intervention material, and the short timeframe between pre- and post-intervention questionnaires. Additionally, the timing of data collection in relation to participants' spring break may have influenced their physical activity levels and recall accuracy.

Despite the lack of support for the hypothesized message-framing effects, this study offers valuable insights for future research, such as emphasizing self-efficacy enhancement, investigating novel communication platforms (particularly those pre-

ferred by college students), and addressing methodological limitations. By focusing on these areas, researchers can continue to develop successful approaches to promote healthy and active lifestyles among this important population.

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Appendix A

SPSS Tables

A.1 Repeated measured analysis of variance

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	timee	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
timee	Linear	543404.969	1	543404.969	.509	.477	.006
timee * Group	Linear	2541677.400	2	1270838.700	1.192	.309	.027
Error(timee)	Linear	90657859.958	85	1066563.058			

Figure A.1: Test of Within- subjects

Pairwise Comparisons

Measure: TimeT1

Group	(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
1	1	2	191.481	281.078	.498	-367.376	750.339
	2	1	-191.481	281.078	.498	-750.339	367.376
2	1	2	-207.969	258.186	.423	-721.312	305.375
	2	1	207.969	258.186	.423	-305.375	721.312
3	1	2	350.690	271.212	.199	-188.553	889.932
	2	1	-350.690	271.212	.199	-889.932	188.553

Based on estimated marginal means

[a]. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Figure A.2: Least Significant Difference Post-Hoc Test

Appendix B

Questionnaire

New General Self Efficacy Scale

1. I will be able to achieve most of the goals that I have set for myself.
2. When facing difficult tasks, I am certain that I will accomplish them.
3. In general, I think that I can obtain outcomes that are important to me.
4. In general, I think that I can obtain outcomes that are important to me.
5. Compared to other people, I can do most tasks very well.
6. Even when things are tough, I can perform quite well.

Assessment of Self-Efficacy in Physical Activity

1. I believe I have the abilities and resources necessary to be physically active and maintain a healthy lifestyle
2. If I experience setbacks or miss workouts, I believe I can easily get back on track and continue being active.

3. I am confident I can find or try different physical activities that I will enjoy and that fit my needs.
4. I believe I can stay motivated and engaged in physical activity even when I don't see immediate results.
5. When faced with obstacles to being physically active (e.g., lack of time, tiredness), I am confident I can find ways to overcome them.
6. I am confident I can start a new physical activity routine and stick with it

Attitudes Towards Physical Activity:

Difficulty/Ease:

1. Physical activity is a difficult and tiring task.
2. I find it easy to get motivated for physical activity.

Relaxing/Stressful:

3. Physical activity is a way for me to clear my head and de-stress
4. Exercise makes me feel anxious and overwhelmed.

Enjoyable/Not Enjoyable:

5. I look forward to engaging in physical activity in my free time.
6. I find most physical activities to be boring and repetitive.

Healthy/Unhealthy:

7. I believe physical activity is essential for maintaining good health.
8. I like to exercise to improve my physical appearance and body image
9. I am motivated to be active because I know it benefits my physical and mental well-being.

International Physical Activity Questionnaire (IPAQ)

In this section, we will ask about your physical activity habits over the **past month**. Remember, anything counts, whether you move for fun, work, or simply get around. Think about activities that get your heart rate going above its resting pace. Please keep in mind the following definitions when you are answering the questions:

- **Moderate activity:** This is defined as activity where you raise your heart rate and feel a little out of breath (e.g., cycling, pilates, playing recreational sports like basketball or soccer).
- **Vigorous activity:** This is where you are breathing hard and fast and your heart rate has increased significantly (you will not be able to say more than a few words without pausing for breath) (e.g., HIIT workouts, heavy weight lifting, spinning, running)

1. In **the past month**, on average, how many days per week did you participate in **vigorous** physical activities such as heavy lifting, aerobics, or running?
2. How much time did you usually spend doing **vigorous** physical activities on one of those days?
3. In **the past month**, on average, how many days per week did you participate in **moderate** physical activities such as biking (leisurely pace), pilates, playing recreational sports? Do not include walking.
4. On average, how much time did you usually spend doing **moderate** physical activities on one of those days?
5. On average, how much time do you usually spend **walking** per day? This includes walking at work, home, university, for transportation, exercise, or leisure.
6. On average, how many hours per day do you spend **sitting**?

Original IPAQ questionnaire: https://sites.google.com/view/ipaq/score?authuser=0

Intervention Feedback

1. I found the emails about physical activity to be:
2. How much did you typically read the information in the emails?
3. The emails about physical activity made me feel:
4. How well-suited do you find emails as a communication channel for delivering information about physical activity?
5. Please describe what you liked most and what you liked least about the messages you received.

Appendix C

Intervention Material

Gain Framing	Loss Framing
Subject: Live stronger, live longer. The more muscle mass you have, the greater the likelihood that you will live a long and active life. It turns out that just one hour of each week leads to a decrease in all-cause mortality risk. You can find additional information here	**Subject: Neglecting Resistance Training Could Shorten Your Lifespan** Without adequate muscle mass, you're more vulnerable to chronic diseases, potentially shortening your lifespan compared to others. Research indicates that dedicating just one hour per week to resistance exercise significantly reduces your chances of experiencing premature death from any cause. For more details, refer to the study findings here

Exercise to gain resistance against dementia and Alzheimer's Exciting news! Research shows regular exercise can be a powerful weapon against dementia. A recent analysis combining 16 studies found that exercise reduces dementia risk by 28%, and for Alzheimer's specifically, the risk drops by an incredible 45%.	**Inactivity increases the risk of Dementia and Alzheimer's!** A lack of physical exercise isn't just a missed opportunity—it's a significant risk factor for dementia and Alzheimer's disease. A study examining the physical activity levels of older individuals revealed that those ranking in the bottom 10% for exercise faced more than double the likelihood of developing Alzheimer's compared to their counterparts in the top 10%. Your brain health is profoundly influenced by your physical activity levels.
Ace Tests & Life with Exercise! Exercise boosts blood flow and oxygen to your brain, fueling focus, memory, and learning. Research even shows exercise helps the hippocampus grow (This is a part of the brain that's vital for memory and learning) Study smarter, not harder! You can find additional information here	**Don't let your brain get rusty!** Inactivity can negatively impact your brain function, making learning and remembering information challenging.For more details, refer to the study findings here

Exercise to improve your sleep Exercise not only helps you fall asleep faster but also enhances the overall quality of your rest. Studies have shown that Physical activity is better than most insomnia treatments, reducing sleep onset by 55%, increasing total sleep by 18% and relieving anxiety. Wake up rested, naturally! For more details, refer to the study findings here	**Insomnia Got You Down? Inactivity Makes It Worse!** Neglecting regular physical activity deprives you of the opportunity to optimize your sleep quality and address sleep disorders effectively. In people with severe insomnia, exercise offers more benefits than most drugs. Exercise reduced time to fall asleep by 55%, total night wakefulness by 30%, and anxiety by 15% while increasing total sleep time by 18%. For more details, refer to the study findings here

Elevate Your Intimacy with Exercise! Take sex to the next level! Regular physical activity offers numerous benefits that can enhance your sex life. Strengthening your heart, improving blood circulation, toning muscles, and increasing flexibility are just some of the ways exercise can contribute to a more fulfilling sexual experience. Studies indicate that committing to as little as 160 minutes of exercise per week can lead to improvements in erectile function for men and heightened sexual satisfaction, arousal, and well-being for women. If interested in learning more, check out these papers: The Effects of Exercise on Sexual Function in Women and Physical Activity to Improve Erectile Function: A Systematic Review of Intervention Studies	**Don't Miss Out on Enhanced Intimacy** Neglecting regular exercise could be holding back your sexual satisfaction and well-being. Without consistent physical activity, you're missing out on the opportunity to strengthen your heart, improve blood circulation, and enhance muscle tone and flexibility—all of which are essential for a fulfilling sex life. Research highlights the link between exercise and improved erectile function in men and increased sexual satisfaction in women. Don't let inactivity dampen your intimacy. If interested in learning more, check out these papers: The Effects of Exercise on Sexual Function in Women Physical Activity to Improve Erectile Function: A Systematic Review of Intervention Studies

Boost Your Body's Defense with Exercise! Engaging in regular physical activity serves as a powerful tool to strengthen your immune system and enhance overall health. Studies demonstrate that acute exercise acts as an immune system adjuvant, improving defense activity and metabolic health. Regular exercise training establishes an inverse relationship with illness risk, meaning that by working out consistently, you bolster your body's ability to fend off sickness.	**Inactivity Weakens Your Defenses!** Skipping exercise leaves your immune system vulnerable, increasing your chances of getting sick and slowing down your metabolism.For more details, refer to the study findings here
Move Your Body, Boost Your Confidence Regular exercise helps maintain a healthy body weight, ensuring you look and feel your best.	**Avoid Weight Gain & Health Risks!** Avoiding regular exercise can lead to difficulties in maintaining a healthy body weight, increasing the risk of obesity-related health issues.
Move your body, and live a healthier happier life! Regular movement reduces the risk of major health issues like hypertension, heart disease, stroke, diabetes, certain cancers, and even depression. Move your body, and live a healthier, happier life!	**Avoid Disease Risks with Regular Exercise!** Inactivity fuels your risk of hypertension, heart disease, stroke, and even certain cancers. By failing to prioritize exercise, you're playing a dangerous game with your health.

Exercise Your Way to Better Mental Health! Research demonstrates that physical activity is a powerful tool for improving mood and reducing feelings of depression, anxiety, and stress. According to this study, just 10–30 minutes of exercise is sufficient to improve your mood and boost your overall well-being. This can be explained by exercise enhancing brain sensitivity to serotonin and norepinephrine, hormones that alleviate depression, while also increasing the production of endorphins—your body's natural mood enhancers. By incorporating regular exercise into your routine, you will boost your mood and reduce stress naturally.	**Don't Miss Out on Happiness!** You might be missing out on more than just a sweat session. Studies show that stopping exercise can lead to increased depression and anxiety within weeks. By skipping exercise, you are missing out on the release of feel-good chemicals like endorphins, which boost your mood and reduce stress naturally. You can find additional information here

Boost Insulin Sensitivity with Physical Activity! Exercise boosts insulin sensitivity, stabilizing blood sugar levels. Just 30 minutes daily unlocks numerous benefits: improved glucose regulation, lower diabetes risk, and increased energy. See more here	**Missing Out on Energy? Inactivity Spikes Your Blood Sugar & Drains Your Energy!** A study shows that long-term inactivity significantly increases blood sugar levels even if you reduce your food intake to avoid gaining weight. Physical activity stabilizes blood sugar, but inactivity creates imbalances, leaving you feeling tired & sluggish. For more details, refer to the study findings here

Appendix D

Python Code

```
import smtplib
import pandas as pd
import random
from email.mime.text import MIMEText
from datetime import datetime
from dataclasses import dataclass
from typing import List

SEND_EMAILS = False
INIT_SURVEY_PATH = 'survey.csv'
FINAL_SURVEY_PATH = 'final_survey.csv'
EMAILS_AND_GROUPS_PATH = 'emails_and_groups.csv'
OVER_30_PATH = 'over_30_days.csv'



SENDER = "YOUR_EMAIL"
PASSWORD = "YOUR_PASSWORD"

@dataclass
class EmailObj:
    email: str
```

```
    subject: str
    body: str


def extract_subjects_and_bodies()-> tuple:
    """Extracts the subjects and bodies from the .txt
    files and returns them as lists of strings.

    Returns:
        tuple: (subjects_text, bodies_text)
        With both being lists of 3 lists of 31 strings
    """
    subjects_text = [[], [], []]
    bodies_text = [[], [], []]
    for group_num in range(3):

        with open(f'subjects_group_{group_num+1}.txt', 'r') as
            file:
            for line in file:
                # Append each line (recipient) to the recipients
                    list, removing leading/trailing whitespace
                subjects_text[group_num].append(line.strip())

        with open(f'body_group_{group_num+1}.txt', 'r') as file:
            for line in file:
                bodies_text[group_num].append(line.strip())

    return subjects_text, bodies_text


def match_emails_to_person() -> List[EmailObj]:
    """Match the emails to the subjects and bodies corresponding
        to them
```

```
52      depending on the group number and the number of days since the
            survey was filled.
53
54      Returns:
55          List[EmailObj]: list of EmailObj objects, for each entry
                in EMAILS_AND_GROUPS_PATH file
56      """
57      subjects_text, bodies_text = extract_subjects_and_bodies()
58      emails_groups_df = pd.read_csv(EMAILS_AND_GROUPS_PATH)
59      emailObjects = []
60      for _, row in emails_groups_df.iterrows():
61          email = row['Email Address']
62          group_number = row['Group Number']
63          date = row['Timestamp']
64          date = datetime.strptime(date, '%m/%d/%Y %H:%M:%S')
65          num_days = (datetime.now() - date).days
66          subject = subjects_text[group_number-1][num_days]
67          body = bodies_text[group_number-1][num_days]
68          print(f"Email: {email}, Group: {group_number}, Days: {
                num_days}, Subject: {subject}, Body: {body}")
69          if subject == "" or body == "":
70              continue
71          emailObjects.append(EmailObj(email, subject, body))
72      return emailObjects
73
74
75  def send_email(emailObjects: EmailObj, sender: str, password: str)
        :
76      """Send an email to the recipients in the emailObjects list
77
78      Args:
79          emailObjects (EmailObj): EmailObj object to be sent in the
                email
```

```
80          sender (str): Email address of the sender
81          password (str): Password of the sender's email
82
83      Returns:
84          None: No return value
85      """
86      for emailObject in emailObjects:
87          recipient = emailObject.email
88          subject = emailObject.subject
89          body = emailObject.body
90          msg = MIMEText(body)
91          msg['Subject'] = subject
92          msg['From'] = sender
93          msg['To'] = ', '.join(recipient)
94          with smtplib.SMTP_SSL('smtp.gmail.com', 465) as
                smtp_server:
95              smtp_server.login(sender, password)
96              smtp_server.sendmail(sender, recipient, msg.as_string
                    ())
97              print("Message sent!")
98      return None
99
100
101 def update_emails_and_groups() -> None:
102     """Updates the emails_and_groups.csv file by adding the
        emails that are in the FINAL_SURVEY_PATH file
103
104
105     Returns:
106         None: No return value
107     """
108     init_survey_df = pd.read_csv(INIT_SURVEY_PATH)
109     emails_groups_df = pd.read_csv(EMAILS_AND_GROUPS_PATH)
110     final_survey_df = pd.read_csv(FINAL_SURVEY_PATH)
```

```
111     over_30_df = pd.read_csv(OVER_30_PATH)
112
113     # Iterate over the "Email Address" column in survey.csv
114     for _, row in init_survey_df.iterrows():
115         email = row['Email Address']
116         init_time = row['Timestamp']
117         # Check if the email exists in emails_and_groups.csv
118         if email not in emails_groups_df['Email Address'].values\
119             and email not in final_survey_df['Email Address'].
                values\
120                 and email not in over_30_df['Email Address'].
                    values:
121             # Generate a random group number between 1 and 3
122             group_number = int(random.randint(1, 3))
123             date = row['Timestamp']
124             date = datetime.strptime(date, '%m/%d/%Y %H:%M:%S')
125             num_days = int((datetime.now() - date).days)
126             # Add a new row to emails_and_groups_df
127             new_row = {'Email Address': email,
128                        'Timestamp': init_time,
129                        'Group Number': group_number,
130                        'Number of Days': num_days}
131             emails_groups_df = pd.concat([emails_groups_df, pd.
                DataFrame([new_row])], ignore_index=True)
132     emails_groups_df.to_csv(EMAILS_AND_GROUPS_PATH, index=False)
133     return None
134
135
136 def find_over_30_days():
137     """Finds the emails that have been in the
        EMAILS_AND_GROUPS_PATH
138     file for over 30 days. Then removes them and reallocates them
        into the
```

```
    OVER_30_PATH file.

    Returns:
        None: No return value
    """
    emails_groups_df = pd.read_csv(EMAILS_AND_GROUPS_PATH)
    over_30_df = pd.read_csv(OVER_30_PATH)
    for idx, row in emails_groups_df.iterrows():
        num_days = row['Number of Days']
        if num_days > 30 and row['Email Address'] not in
            over_30_df['Email Address'].values:
            newrow = {'Email Address': row['Email Address'],
                      "Timestamp": row["Timestamp"], 'Group Number
                          ': row['Group Number']}
            over_30_df = pd.concat([over_30_df, pd.DataFrame([
                newrow])], ignore_index=True)
            emails_groups_df.drop(idx, inplace=True)
    over_30_df.to_csv(OVER_30_PATH, index=False)
    emails_groups_df.to_csv(EMAILS_AND_GROUPS_PATH, index=False)
    return None


def find_filled_final_survey():
    """Finds the emails that have filled the final survey and
        removes them
    from the OVER_30_PATH file. Then sends them an email with the
        final survey link
    to those that have not filled out the final survey and are in
        the OVER_30_PATH file.

    Returns:
        None: No return value
    """
```

```
166     over_30_df = pd.read_csv(OVER_30_PATH)
167     final_survey_df = pd.read_csv(FINAL_SURVEY_PATH)
168     for idx, row in over_30_df.iterrows():
169         email = row['Email Address']
170         if email in final_survey_df['Email Address'].values:
171             over_30_df.drop(idx, inplace=True)
172 
173         else:
174             subject = "Final Step!"
175             body = "Congratulations, you are almost there! To
                finalize this study (and participate in the raffle
                 for the prize), please complete the following
                short survey: https://forms.gle/gSwfwrJHFtMmsMZC8\
                n\n Thank you for your participation!"
176             if SEND_EMAILS:
177                 send_email([EmailObj(email, subject, body)],
                        SENDER, PASSWORD)
178             else:
179                 print("Sending email to: ", email)
180                 print("Subject: ", subject)
181                 print("Body: ", body)
182 
183     final_survey_df.to_csv(FINAL_SURVEY_PATH, index=False)
184     over_30_df.to_csv(OVER_30_PATH, index=False)
185     return None
186 
187 
188 def daily_process():
189     """The process that needs to be run every day
190     """
191     # Update all the .csv files
192     update_emails_and_groups()
193     find_over_30_days()
```

```
194     find_filled_final_survey()
195
196     # Match the emails to the subjects and bodies corresponding to
            them
197     emailObjects = match_emails_to_person()
198     # Send the emails
199     if SEND_EMAILS:
200         send_email(emailObjects, SENDER, PASSWORD)
201     else:
202         for emailObj in emailObjects:
203             print("Sending email to: ", emailObj.email)
204             print("Subject: ", emailObj.subject)
205             print("Body: ", emailObj.body)
206
207
208
209 if __name__ == "__main__":
210     daily_process()
211     print("Done!")
```